STUDIES ON CROP - WEED COMPETITION OF A WHEAT CROPLAND ECOSYSTEM IN BUNDELKHAND REGION

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BY

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2002

DECLARATION

I hereby declare that the thesis entitled "**Studies on crop-weed competition of a wheat cropland ecosystem in Bundelkhand region**" being submitted to Bundelkhand University, Jhansi for the Degree of Doctor of Philosophy in Botany is an original piece of research work done by me and to the best of my knowledge and belief the thesis or any part of the thesis has not been published in any other University or Examining Body in India or abroad earlier.

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This is to certify that the thesis entitled "**Studies on crop-weed competition of a wheat cropland ecosystem in Bundelkhand region**", submitted for the award of degree of **Doctor of Philosophy** in Botany of Bundelkhand University, Jhansi, is a record of bona fide research carried out by Pravin Kumar Pandey under my guidance and supervision. No part of this thesis had been submitted for any other degree or diploma. It is also certified that Sri Pandey has worked under my supervision for the period required under the relevant ordiance of Bundelkhand University, Jhansi.

It is further certified that such help or information as has been availed of during the course of this investigation have been duly acknowledged by him.

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PREFACE

The demand of food has been increased manifolds with the rising human population. On the limited land, therefore, for obtaining maximum food production by crop plants, researches are being done in various diverse ways. Among cropland ecosystems wheat crop is one of the most important. However, the resources of these ecosystems are unwantedly shared by weeds and the overall production of desired species falls down considerably. In the present investigation effect of weed infestation on the productivity of wheat crop has been studied both qualitatively as well as quantitatively under field and pot culture conditons.

After a brief introduction and review of literature (Chapter I), the study area and general experimental methods (Chapter II), information about the important species of weeds occurring in wheat fields of this area, on the basis of their density and frequency values are given in Chapter III (Photosocialogical studies). Chapter IV deals with the productive structure of the pure and mixed stands of wheat maintained at a constant crop density. This includes dry matter production, photosynthetic area index, chlorophyll content, water content and light penetration at different depths in the canopy.

Mineral structure of pure and mixed stands of wheat is described

in Chapter V. Nitrogen and phosphorus concentrations at different heights of the crop and uptake, release and retention of nitorgen and phosphorus are given. Studies on competition of wheat and Vicia hirsuta as influenced by density (in pure and mixed cultures) and spatial distribution are described in the light of existing knowledge (in chapter VI) followed by a brief summary of the work and the references cited in the thesis. Photographs of experimental plates taken during the study peiod are appended.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Among the world's crops wheat has the pre-eminent position as a food of mankind. The cultivation of this crop is obscured by antiquity but it is known that in prehistoric times it was cultivated through out Europe and was one of the most valuable cereals of ancient persian, Greece and Egypt.

In the form of bread it constitutes the chief food of the most highly civilised races. On account of peculiar qualities wheat makes more palatable and better bread than any other cereals. Its cultivation is simple and its adaptability to various soils and climatic condition is so wide that it is grown in greater parts of all the continents.

With enormous rising human population, the demand for food has increased many folds. This vital problem can be solved only by increasing the primary productivity of crop plants on the limited land. Cropland ecosystems of wheat crop is one of the most important. However, the resources of these ecosystems are unwantedly shared by weeds and the overall production of desired species falls down considerably. Annual national loss in agricultural production in United states due to weeds and cost of their control exceeds 4.5 billion dollars (Shaw, 1964). In India (Thakur, 1954: Hag; 1955) and in many other countries (Brenchley, 1920: Salishbury, 1942; Ahlgren et al. 1951; Robbins et al. 1958) the loss due to weeds is

significantly high. For the present study wheat has been selected because of its importance as human diet and cattle fodder in India and occupies the greatest part of the cultivated area of India i.e. about 15% next to rice (Agri. Sit. India, 1969).

Periodic observations of the floristic composition of the community is basic step while studying the structure and function of any ecosystem. In crop fields where weeding is regularly done, the weeds get eliminated but otherwise a large number of weeds come up and reduces the yields of crops. The extent of this reduction depends upon the weed species i.e. if the species are more competitive, the reduction will be more. In present investigation, species structure of weed infested stand has been studies at three stages of crop growth i.e. vegetative, flowering and fruiting.

Plant fix the radiant energy of sun into chemical potential form and this energy is utilized by plants themselves and other organisms. A part of this energy is used by plants in various metabolic processes and some is lost, the remaining part is conserved in the form of dry matter in plant body and is known as net primary production. Various workers have estimated the net production of plants by various methods. Odum (1967 a,b), Ovington (1956, 57, 62), Bliss (1966) and Choudry (1967) have used harvest method to estimate the net primary production of plants. Seki (1960), Scott and Billing (1964) and Dwivedi (1970) estimated the rate of gas exchange and evaluated the net and gross production by plants.

Dry matter production of crop depends on a number of factors. Thickness, geometric configuration, leaf area and chlorophyll content of the photosynthetic portion and light intensity etc. affect the rate of production (Johanke et al. 1965). Distribution of photosynthetic biomass and its relation of the amount of chlorophyll and photosynthetic, area at different depths in the canopy in deep control the productivity to a large extent (Marwah and Ambasht, 1972).

Mineral structure of plants is important in determinig the rate of dry matter production by plants. The two most important nutrients which influence many physiological processes of plants are nitrogen and phosphorus, which are important constituent of protein which form the protoplasm and enzymes which regulate the metabolism. Phosphorus holds an important position in the transformation of energy through energy rich phosphorus compounds like ATP, NATP etc. which provide energy for the synthesis of proteins, carbohydrates etc. Therefore, both nitrogen and phosphorus are essential for growth and a deficiency checks the formation of chlorophyll. Nitrogen deficient plants become yellowish and photosynthesis ceases (Kramer and Kozlowasky, 1960). Dwivedi (1970) stated that inadequate supply of phosphorus to plants limits their growth and reduces the energy efficiency and thus dry matter prodcution of crops.

The distribution of minerals in the crop plants affected by weeds rob enormous amount of nutrients from the crops (Misra et al. 1968) and

reduces the nutrients content of the crop. Eddowes (1969) and Yomazaki (1969) working with maize and wheat respectively reported that at heigher densities of plants, the nitrogen content is reduced.

In nature no species grow singly, even crops which are raised mono - cultures have a number of associated species called weeds. These undesirable plants compete for water, nutrients, space etc. with the principal crop and thus reduces the crop production. Therefore, in any competition studies, it is essential to understand the community structure of the cropland as a whole. Frequency and density of plants are some of important parameters that would give a picture of community structure. In India an ecological survey of weed flora of cultivated fields has been done by many workers (Singh and Chalam, 1937: Misra, 1964: Tripathi, 1965: Pandey, 1968 and Marwah, 1972).

Potential chemical energy is accumulated in the plant body in the form of dry matter and the standing crop biomass of the crop at any time represents the amount of dry matter accumulation upto that time. However, accumulation of biomass depends on the efficiency of plants to utilise the resources of the surrounding environment i.e. light, water, nutirents and space etc. In cropland ecosystem the dry matter production of wheat is significantly affected by weeds growing in association with it.

Profile distribution of biomass and its relation to the amount of chlorophyll, photosynthetic area, moisture content and light penetration at

different depth in the canopy indeed control the productivity to a large extent.

Loomis et al. (1967) have emphasised the importance of variation in canopy structure to estimate the photosynthesis. Advances during the recent years have focussed attention on light distribution within the crop as the major determinant of the changing pattern of dry matter production of crops during ontogeny (Osman, 1971; Waston, 1952; Monsi and Saeki, 1953; Davidson and Phillips, 1956; Donald, 1961, 63; Evans, 1963; Monteith, 1965; Pietro et al. 1967; Eckardt, 1968; Rakesh and Sharma, 1999; Pandey et al. 2000 and Ajit et al. 2001).

Yield of plants ultimately depends upon the efficiency of the photosynthetic process and upon the extent of photosynthetic surface (Watson, 1952). Pierce et al. (1967 a, b), Johnke et al. (1965), Newton et al. (1960), Loomis et al. (1967) have collected valuable information on the attenuation of light as a function of depth in the canopy.

In most of the species, specially in dicots leaf is the only component taking part in the photosynthesis and therefore, measurement of the area of leaves and leaf area index is important (Waston, 1952). However, in many grasses, forbs and crops besides leaves, stem and inflorescence also contain chlorophyll and contribute significantly to dry matter production. Various workers have estimated the contribution of different components of wheat by their photosynthetic activity to the total dry weight of grains

(Archbold, 1942; Enyi, 1962; Quinlan and Sengar, 1965; Voldeng and Simpsen, 1967; Asana and Mani, 1950 and Throne, 1962).

Amount of chlorophyll per unit area has been used as an indicator of food assimilation potential of primary producers (Odum et al., 1958). Newbould (1969), stated that while there is no suggestion that the amount of chlorophyll limits the production still it represents and measure of the size of the photosynthetic system.

Translocation of minerals to the top and the organic compounds to the roots is essential for growth of plants as their synthetic activities (Kramer and Kozolowaski, 1960) Weeds growing in association with the crop share a large amount of minerals from soil thus affects the growth and mineral status of the crop.

Although a considerable amount of work has been done in cropland ecosystem in India and abroad, but dry matter production of plants in relation to their productivity and mineral structure as affected by weed infestation and penetration of light at different depth in the canopy needs further attention.

Thus, in present investigation, a comparative study of productivity and mineral structure with special reference to net primary production, photosynthetic area index, chlorophyll content and light penetration, nitrogen and phosphorus in wheat cropland ecosystem have been studied.

CHAPTER II

THE STUDY AREA, GENERAL EXPERIMENTAL DESIGN AND METHODS

THE STUDY AREA

LOCATION AND TOPOGRAPHY

The study area selected for present study is situated in the premises of Aata Agriculture Farm, Orai at lat. 25^{P} 59' N, long 79^{0} 37' E and is about 125 m above mean sea level in northern part of the Bundelkhand region. The study site is at a distance of about 5 km towards east of Orai, District Jalaun (U.P.) as depicted in Fig. 2.1.

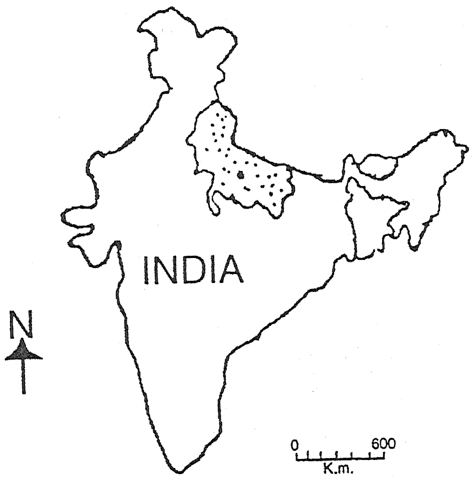
The study area extending over an area of 43 acre was fully protected from all the types of interferences.

Bundelkhand is suitable for good growth of grasses and fodder crops and has a central position in the country. The site for investigation is a part of land bounded by Yamuna river in north, Betwa river in South and Madhya Pradesh in the west.

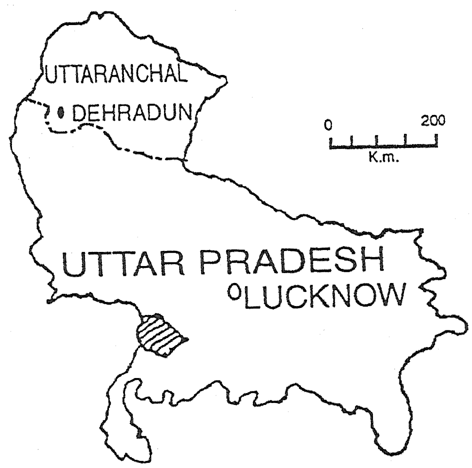
Besides southern marginal area, the topography of this region is of undulating type. Trans-Yamuna plain is another name of Bundelkhand plain which is topographically divisible into three east-west running belts i.e. southern, northern and central belts. Orai is located in northern belt and confined along the bank of river Yamuna in the form of high ground which represents the levels of ancient flood plain but at present is badly cut into ravines.

Fig.2.1: Map showing the location of study area.

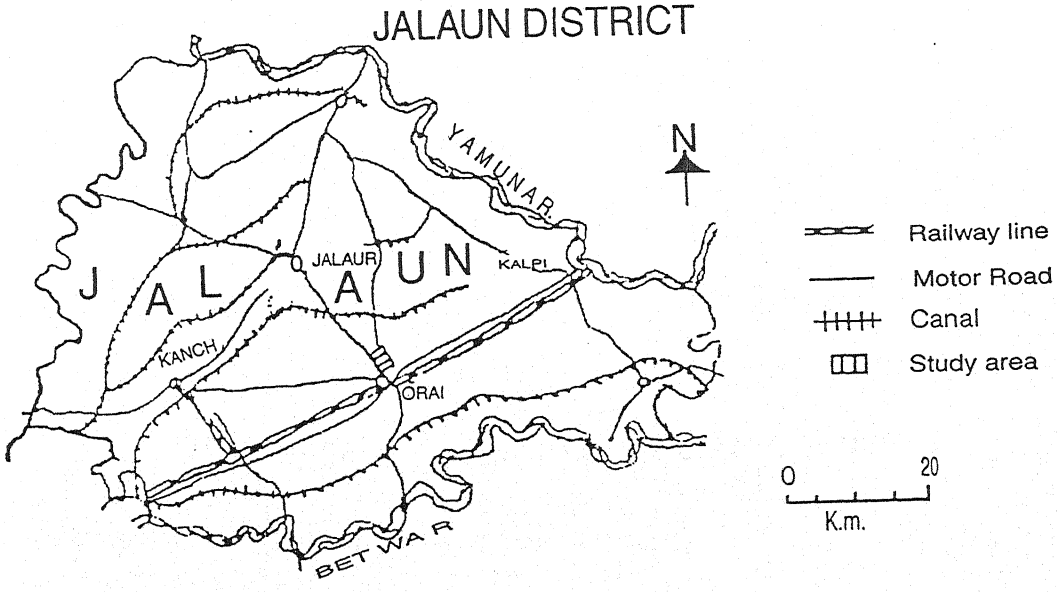
UTTAR PRADESH
IN
INDIA



JALAUN DISTT.
IN
UTTAR PRADESH



STUDY AREA
IN
JALAUN DISTRICT



LITHOLOGY (GEOLOGY)

Sand stones, lime stones and shales are the common rocks. The special features of immense geographical interest in this region are quartz, reefs and dolarite dykes which are long and narrow with serrated ridges. The geological system is covered in the north-east by Ganga Yamuna alluvial deposits in the form of an embayment.

NATURAL VEGETATION

The region is ecologically degraded and the original vegetation has almost been removed for inhabitation and cultivation. Shrubs and grasses represent the secondary growth throughout the region. Babul is the principal type of Acacia. Khair is the common tree but not much utilized. Hingota, Karondha and Kareel are mostly utilized for grazing.

Albizzia procera (Siris), Anogeissus pendula (Dhawana), Tectona grandis (Teak), Butea monosperma (Dhak), Salmalia malabarica (Semal), Boswellia serrata (Salai), Dalbergia sissoo (Shisham), Arabia catechu (Khair), A. nilotica (Baboo), Zizyphus mausitian (Bair), Carissa carandus (Karondha), Capparis aphylla (Kareel), Balanites aegyptica (Hingota), Albizzia lebbek (Black Siris) are the main contributors in the natural vegetation of this region.

CLIMATE

The climate of Bundelkhand region is typically dry sub-humid and has a distinct seasonality. It is characterised by three seasons.

(i) Rainy season (July-Ocrober) : It is warm and wet.

(ii) Winter season (November-February) : It is cool and dry.

(iii) Summer season (March-June) : It is hot and dry.

The climatic records of Orai (Aata) are summarised in Table 2.1 and depicted in Fig. 2.2

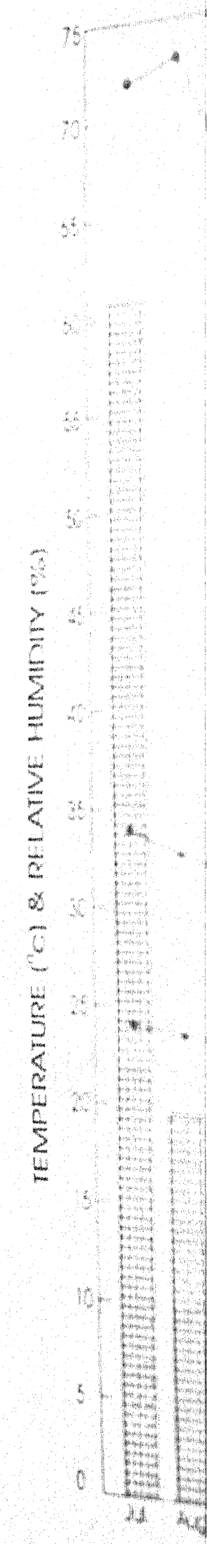
The mean annual temperature of Orai is 24.8^{0}C but mean monthly values considerably vary from their annual means (14.5 to 35.5^{0}C) and consequently their ranges are high. For occasional nights temperature may fall down to a lowest minimum of 2^{0}C. The intensity of the summer season increases with a very hot westerly dust laden winds called 'Loo', which usually blow throughout May and June and the temperature continuously increases upto a highest maximum of 45^{0}C in May.

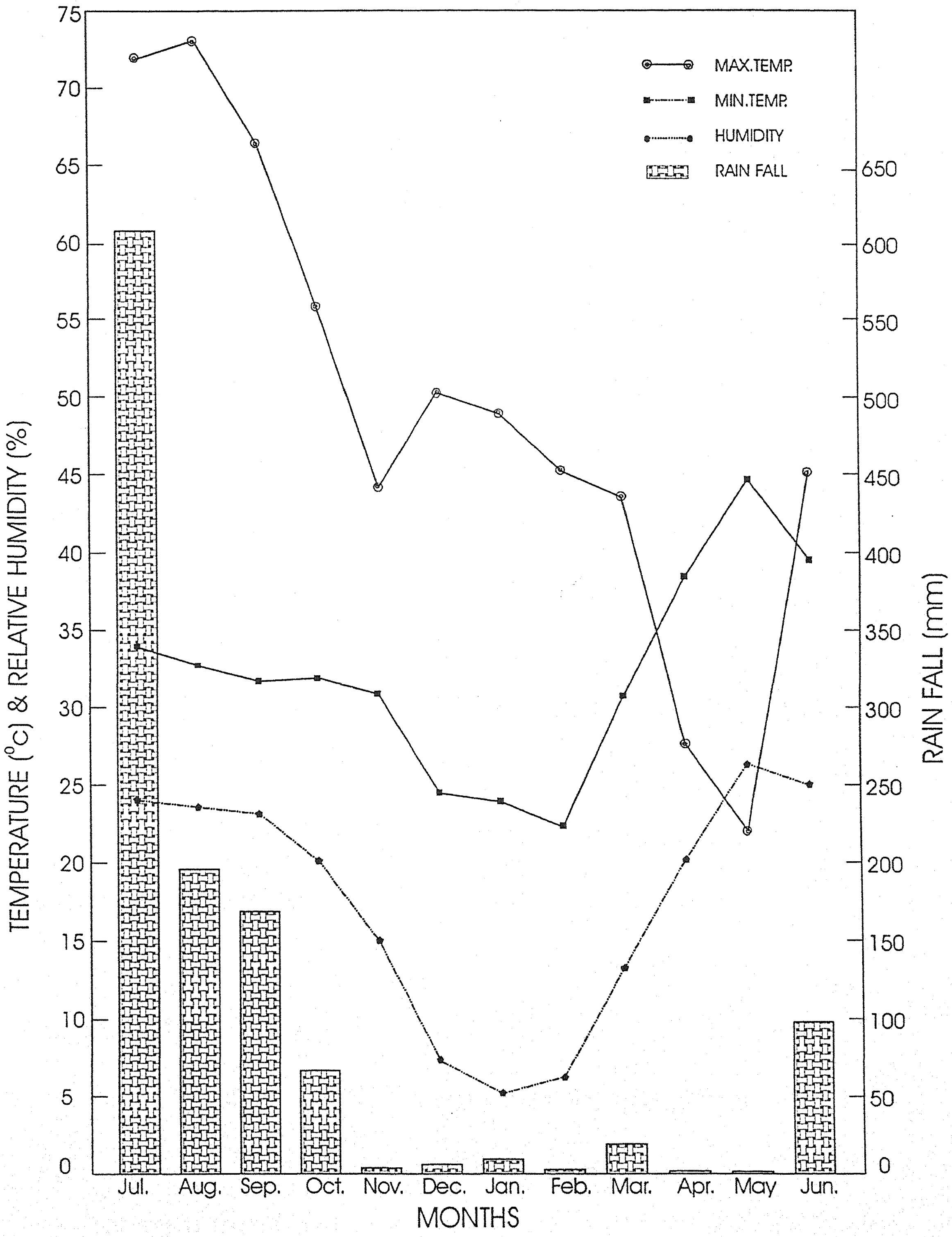
Total annual precipitation comes to about 1186.8 mm of which 90% falls between July to October i.e. during wet summer when temperature fluctuates around 30^{0}C. The onset of monsoon takes place during the end of June with maximum rainfall during July and August. Some shallow westerly depressions cause occasional winter rains which take place by the end of December upto the end of February of March. Winter accounts for only 2% of the annual rainfall.

TABLE 2.1 : Climatic records of Orai (Aata), 1999-2000

Months	Temperature ^{0}C			% Relative humidity			Wind velocity Km/hr mean month.	Rainfall (mm) Monthly	Incident Energy K cal/m^2x 10^3/day
	Mean Max.	Mean Min.	Mean month	Mean morn.	Mean even.	Mean month			
July' 1999	34.0	24.1	29.0	78.0	67.0	72.0	2.0	615	5.13
August	32.8	23.9	28.8	73.7	72.5	73.1	2.8	194.8	4.56
September	31.9	23.5	27.7	66.5	66.7	66.6	2.9	169.7	4.54
October	32.1	20.0	26.0	60.0	52.0	56.0	1.8	69.0	4.56
November	31.1	15.0	23.0	50.0	38.0	44.0	1.7	3.4	4.01
December	24.5	7.6	16.0	57.5	43.8	50.6	2.0	5.0	3.67
January' 2000	23.5	5.5	14.5	51.8	45.7	48.7	2.0	8.4	3.76
February	22.4	6.8	14.6	44.3	46.3	45.3	3.0	2.0	4.44
March	30.7	13.6	22.0	50.6	38.6	44.6	3.0	19.3	5.28
April	38.0	20.1	29.0	37.3	18.0	27.6	3.5	1.0	5.59
May	44.9	26.2	35.5	25.4	19.0	22.2	5.3	-	5.81
June	39.2	25.0	32.1	50.0	40.6	45.3	4.4	99.2	5.40

Fig.2.2: Climatic records of Orai (Aata) 1999-2000





MAX.TEMP.
MIN.TEMP.
HUMIDITY
RAIN FALL
TEMPERATURE (°c) & RELATIVE HUMIDITY (%)
RAIN FALL (mm)
MONTHS
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.

With respect to wind, because intensity of rains and temperature variation will depend upon the direction of the wind, it blows over the area running from Bay of Bengal obliquely south-east and north-west direction in July. In winter months the wind direction changes from north-west to south-east. During summer the wind is westerly with a maximum velocity of 5.3 km per hour in May. Percentage relative humidity (mean monthly) of the area vary from 22.2 to 73%.

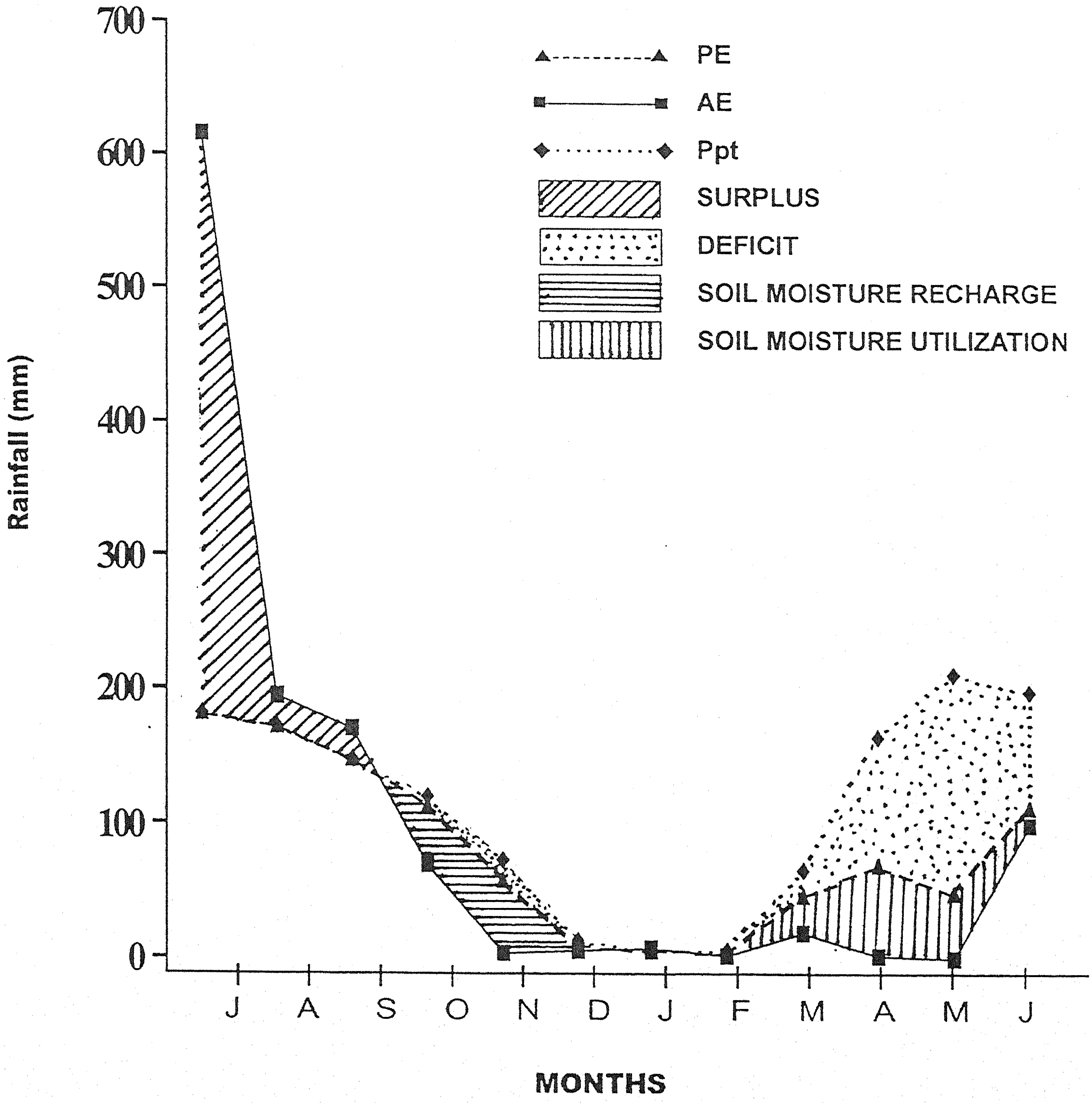
According to Gaussen (1968) the effectiveness of climatic factors like temperature, precipitation and length of dry period can be understood in a better way by means of Ombrothermic diagram (Fig. 2.3). This is done by bringing out the elements on a graph. On the abscissa are marked the months, on ordinates to the left the temperature and to right the rainfall.

For tropical regions, where the mean monthly temperature is about 25^{0}C, rainfall under 50 mm, would classify a month as dry. Thus, the Ombrothermic conditions of the area revealed 8 dry moths and 4 wet months during the year.

SOLAR RADIATION

Solar radiation was not recorded at study area (Orai). Therefore the mean value of Patana (Lat. 25^0 35' N) and Jodhpur (Lat. 26^0 15' N) stations has been considered here for calculation of total incident solar energy because the geographical situation of Aata Agriculture Farm (Orai),

Fig.2.3: Ombrothermic Diagram of Orai (Aata)



700
600
500
400
300
200
100
0
Rainfall (mm)
PE
AE
Ppt
SURPLUS
DEFICIT
SOIL MOISTURE RECHARGE
SOIL MOISTURE UTILIZATION
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

the study area (Lat. 25^0 59' N) is approximately in between the above two situations.

ECOCLIMATE

Climate of an area in relation to growth of vegetation is measured in the form of precipitation, wind velocity, humidity, temperature etc. Any single factor of climate does not give a clear picture about the exact climate of an area in relation to the growth of vegetation. According to Subramanyam (1958) it is not possible to say that a climate is moist or dry from precipitation alone. These measurements also do not provide the water need of a given vegetation. Water need of a given region is the total amount of water required for full use of vegetation including transpiration as well as direct evaporation from soil surface. Thus the combined evaporation from the soil surface and transpiration from plant surface called' Erapotranspiration', represents the transport of water from the earth back to the atmosphere, the reverse of precipitation. This atmospheric circulation is a part of the hydrological cycle in space and time leads to the concept of 'Water Balance'. Water Balance is a balance between the income of water from precipitation and the loss of water by evapotranspiration, surface run-off and infilteration. The water balance computation equation after Thornthwaite is :

Ppt = Potential evapotranspiration - deficit + surplus

= Storage charge (amount of water temporarily stored in soil)

Potential evapo-transpiration (PE) as proposed by Thornthwaite (1948) is defined as the amount of water that would evaporate and transpire from a vegetation of soil moisture were always available in sufficient amount for optimum use. It is a climatic balance since precipitation and evapo-transpiration are active factors of climate.

On the basis of the potential evapo-transpiration (PE) Thornthwaite (1948) tried to obtain moisture index (Im), from annual water need of a vegetation and is calculated from mean monthly temperature of the area and latitude.

The whole computation of water balance is carried on by tables and nomograms as proposed by Thornthwaite (1948) and Thornthwaite and Mathur (1955). Subramanyam (1955-1969) has published a series of papers on this aspect in India. Pandey et al. has computed the water balance of atleast 8 stations of western India in 1973 including Jhansi station of Bundelkhand region.

In present study the water balance of Orai station is computed on the above pattern as per the method proposed by Thornthwaite and Mathur (1955) presented in Table 2.2 It is evident from the Table that AE was governed by the amount of water available for plant growth and soil moisture storages. In the rainy season, when there was sufficient water for plant growth and soil moisture storage, rates of actual evapo-transpiration were found maximum. By the end of rainy season season (October) when

TABLE 2.2 : Computation of Water Balance of Orai (Aata), 1999-2000

Lat. N 25° 59' 30" N   Long. E 79° 37' 30"   Ht. 125m

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
T°C	29.0	28.8	27.7	26.0	23.0	16.0	14.5	14.6	22.0	29.0	35.5	32.1
i	14.32	14.17	13.36	12.13	10.08	5.82	5.01	5.07	9.42	14.32	19.45	16.70
U.P.E.	15.54	15.38	14.53	12.0	8.0	1.4	4.5	0.6	6.4	15.54	18.37	17.35
P.E.	182	172	148	119	73	13	5	5.3	66	165	211	198
Ppt (mm)	615	194.8	169.7	69	3.4	5.0	8.4	2.0	19.3	1.0	0	99.2
P-P.E.= Δ	+433	+22.8	+21.7	-50	-69.6	-8	+3.4	-3.3	-46.7	-164	-211	-98.8
ε Δ	+433	+455.8	+477.5	-50	-119.6	-127.6	-131.0	-134.3	-181.0	-345	-556	-654.8
St	300	300	300	-254	-200	-195	-193	-191	-163	-94	-46	-33
Δ St	+267	0	0	-46	-54	-5	-2	-2	-28	-69	-48	-13
A.E.	182	172	148	115	57.4	10	5	4	47.3	70	48	112.2
W.D.	0	0	0	4	15.6	3	0	1.3	18.7	95	163	85.8
W.S.	166	22.8	21.7	0	0	0	0	0	0	0	0	0
R.O.	83	11.4	10.35	0	0	0	0	0	0	0	0	0

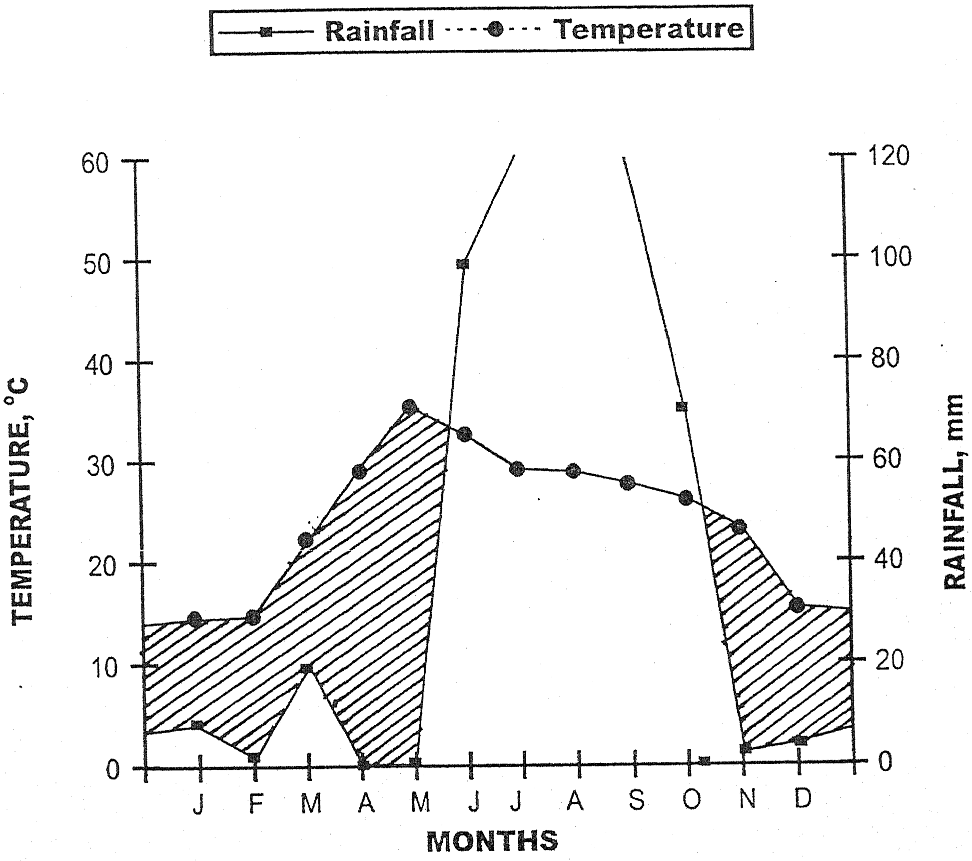
T°C = Mean monthly temperature
i = Heat index
U.P.E. = Unadjusted Potential Evapotranspiration
P.E. = Potential Evapotranspiration
Ppt = Monthly Precipitation
ε Δ = Summation Data (Potential water loss)
S.T. = Storage
W.D. = Deficit
W.S. = Surplus
A.E. = Actual Evapotranspiration

precipitation was lesser than PE, a decrease in the rate of AE was recorded and the decrease was continued till January/February. When soil moisture is at field capacity or above i.e. in the growing period (July-September) annual and potential transpiration are the same, and all precipitation above the water need is counted as surplus (S). The annual value of water surplus comes to 21 cm. This surplus water is totally spent in soil moisture recharge. When precipitation fall below the water need i.e. PE or actual evapo transpiration becomes less than the PE (October-June) this difference is the water deficit (D.) The annual value of deficit is 38.6 cm. The major deficit is reported in April and May. In the graph (Fig. 2.4) monthly course of PE and AE is compared with the precipitation showing clearly the S and D regions.

The net water surplus (S-D) for the whole year, the negative value is obtained (-17.59 cm).

On the basis of moisture index value (-1.70) the area of the study can be classified on the basis of thermal efficiency i.e. PE (135.7 cm) as second megathermal (A_2). The value of summer concentration of thermal efficiency (SCTE) i.e. 43.5 comes to 'a_2' sysbol which clearly indicates that lower SCTE value means high temperature uniformally month after month. SCTE may be defined as the rates of thermal efficiency for the three summer months to the total annual efficiency expressed as percentage. Thus ecoclimate formula of the study area comes to C_1A_2 a_2s. Here the

Fig.2.4: Water balance computation of Orai (1999-2000)



Rainfall
Temperature
TEMPERATURE, °C
RAINFALL, mm
60
50
40
30
20
10
0
120
100
80
60
40
20
0
J F M A M J J A S O N D
MONTHS

small s indicates summer water defficiency.

The various climatic indices worked out are :

Potential Evapo-transpiration (PE) = 135.7 cm = 1357 mm

Humidity Index (Ih) = $\frac{S}{PE}$ X 100 = 15.5

Aridity Index (Ia) = $\frac{D}{PE}$ X 100 = 28.46

Moisture Index (Im) = Ih – 0.6 Ia = - 1.70

Summer Concentration of Thermal Efficiency (SCTE) = 42.5

Total annual precipitation is 1186.8 mm and because of large amount of radiant energy received (Table 2.1). The PE is always higher than the precipitation (Ppt), except in the month of July, August and September and to some extent in January when it almost compensate each other.

SOIL

The soil of Bundelkhand region is considerably variable in soil types, their colour, texture, depth etc. Soil survey and soil work reports for Bundelkhand region have been published by Agrawal and Mehrotra (1952) and Mehrotra and Gangwar (1970). Ray Chaudhary et al. (1963) have also given an exhaustive account of Bundelkhand soil. These reports and works revealed that the soil of this region can be categorised in two groups on the basis of colour i.e. Red soil and Black soil.

Red soil is a light soil and Black soil is a heavy soil. There are two groups in each soil. Red soil consists of ('Rakar' and 'Puruva' on one hand and the Black soil comprises 'Mar' and 'Kabar' on the other hand.

Another classification grouped the soil of this region into (1) upland soil (2) lowland soil and (3) riverain soil. Formation of these soils takes place partly in situ and partly by transportation agencies, chiefly by streams.

Jalaun district in its low lying areas consists of black soil and in its both groups i.e. Mar and Kabar. Mar is calcareous with Kankar, so it is friable and aerated but Kabar is highly diffused.

On the basis of soil analysis the physico chemical characteristics of the study area are given as under in details (Table 2.3)

Table 2.3 : Physico-chemical characteristics of the study site.

Physico-chemical characters	Depth in cm.		
	0-10	10-20	20-30
pH	7.60	7.70	7.70
Water holding capacity (%)	42.69	43.62	43.74
Moisture (%)	17.09	18.65	20.63
Prosity (%)	51.25	52.08	49.16
Nitrogen (%)	0.05	0.04	0.03
Available Phosphorus	0.019	0.013	0.006
Organic Carbon	0.65	0.55	0.49
C/N ratio	13.0	13.75	16.33

* Based on the average of soil sample collected at periodic samplings.

The colour of the soil was pale brown as value, chroma and Hue 10 YR, 6/3.

The texture of the soil showed as loam i.e. medium textured with 37.18% coarse sand, 6.45% fine sand, 27.15% silt and 31.15% clay. Soil pH indicated that it was slightly alkaline in reaction i.e. pH 7.60, 7.70 and 7.70 at 0-10, 10-20 and 20-30 cm depth respectively (Table 2.3).

Porosity on which the plant growth depends for root penetration into deeper region was 51.25, 52.08 and 49.16% at 0.10, 10-20 and 20-30 cm depth respectively (Table 2.3)

Soil samples were taken from different depths (0-10, 10-20 and 20-30 cm) for the estimation of water holding capacity (W.H.C.), moisture percentage, organic carbon percentage and nitrogen content, Result showed that W.H.C. and moisture percentage increased with depth. The average W.H.C. of three depths was 43.35%. Average annual moisture percentage was 18.79 with minimum value of 12.80%.

Organic cabon percentage at different depths of soil i.e. 0-10, 10-20 and 20-30 was 0.65, 0.55, and 0.49% respectively.

Ratio of organic carbon and nitrogen (C/N) was 13.1, 13.75 and 16.33 for different depths i.e. 0-10, 10-20 and 20-30 cm respectively.

EXPERIMENTAL DESIGN AND METHODS

The general experimental procedures used in the study are being described here and the details of the methods followed for different sets of experiments are described in later Chapters. The studies were carried out both under field and pot culture conditons. Wheat seeds (Var. Wh-147) were used in all experiments.

FIELD STUDIES

CROPPING HISTORY OF THE FIELD

The cropping history of the experimental field is presented in Table 2.4

Table 2.4 : Cropping History of the experimental field

Year	Kharif	Rabi
1997-1998	Jowar	Oat
1998-1999	Jowar	Oat
1999-2000	Jowar	Oat

PREPARATION OF THE FIELD

After the rainy season was over, the field was ploughed 4-5 times and all the weeds were removed. In November, before sowing once again field was ploughed and weeding was done. The size of the plot was 4X3 metres.

MANURING :

30 lb. of NPK mixture was added in three fractions during the growing season of wheat; half of the fertilizer was applied before sowing, one fourth after 40 days of sowing and the remaining one fourth at the time of flowering. The proportion of nitrogen, phosphorus and potassium in the mixture was 4 : 2 : 2 respectively.

SOWING :

Healthy seeds of wheat (Var. WH-147) obtained from Aata agricultural Farm were sown in the last week of November, 1999 in rows. The distance between rows was 15 cm. After the seedling had come up, the crop was thinned and density of wheat plants was maintained at 80 individuals per square metre.

IRRIGATION :

The crop was irrigated four times during the growing season at the age of 21, 48, 75 and 90 days.

HARVESTING :

The crop was harvested at three stages of growth i.e. vegetative, flowering and fruiting. Each time three replicate monoliths of 25 X 25 X 25 cm were taken out and dry matter production, chlorophyll content, water

content, photosynthetic area, nitrogen and phosphorus contents of wheat and weeds were estimated. Stratified clip technique (Monsi and Sacki, 1953) was applied to reveal the profile structure of the crop.

POT CULTURES :

Seeds of wheat and Vicia hirsuta were sown in seperate plots of 1 square metre area in the last week of November. After the seedlings had come up they were transplanted in pots of approximately 1000 sq. cm. area. The number of plants of both species per pot was varied in different sets.

The pots were filled with Aata Agricultural Farm soil. Equal amount of NPK mixture and urea was given in three doses (before sowing, at vegetative and at flowering stages). Irrigation was done twice weekly.

CHAPTER III

PHYTOSOCIOLOGICAL STUDIES

PHYTOSOCIOLOGICAL STUDIES

INTRODUCTION

Periodic observations of the cultivated fields is important in order to understand the structure and function of the cropland ecosystem. The functions of the primary producers are controlled by the structural properties of vegetation i.e. composition of the plant community, including the number, periodicity and stratification of species. Various workers in India have listed the weed flora of cultivated fields (Singh and Chalam, 1937; Misra, 1946; Sharma, 1961; Singh, 1961). Tripathi (1965) and Pandey (1968) have done an ecological survey of the crop fields of Varanasi and its surrounding area.

The present investigation deals with the field survey and phytosociology of weeds growing in wheat fields. These were carried out in two wheat field one in the Aata Agriculture Farm of Orai (Jalaun) and other outside the Aata Agriculture Farm. Phytosociological analysis included the evaluation of frequency and density of weeds at three important stages of crop growth i.e. vegetative, flowering and fruiting.

METHODS

Phytosociology of wheat fields was studied using quadrat method (Oosting, 1958; Curtis, 1956; Misra, 1968). Quadrats of 50 X 50 cm size

were thrown randomly in the field ten times and counts were made for each species, including crop. The density and frequency of all species was estimated and calculated as per square metre area. This was done at three stages of growth of wheat viz., Vegetative, flowering and fruiting.

RESULTS

The data presented in Table 3.1 and 3.2 show that wheat crop is associated with a number of weed species throughout its growing season. However, all the weed species do not remain throughout crop season except for few of them. Vicia hirsuta and Cyperus rotundus are found to be the two most dominant weeds growing in association with the crop from the very beginning to the maturity. Cynodon dactylon, Asphodelus tennuifolius and Evolvulus alsinoides come next in the sequence of dominance. It is also observed that density of weeds increases from vegetative stage and attains its maximum value per square metre at flowering stage of crop but again at fruiting stage it decreases.

DISCUSSION

Floristic composition of the cultivated fields depends upon a number of factors such as the agricultural practices followed in the preparation of field, method of sowing, fertilization, intensity of competition etc. High value of total weed density seem to be the result of continuous

cropping in this area. This finding is supported by Brenchley's (1940) statement that continuous growing of wheat or barley does away with the posibilities of weed reduction that are inherent in rotation cultivation. Density of weeds varies at different developmental stages of the crop. Table 3.1 show that total density of weeds is maximum at vegetative stage of crop i.e. 232.7/m^2 but reaches to a maximum value of 362.3/m^2 at flowering stage. At fruiting stage however, most of the weeds are all dried up due to rise in temperature, and density of weeds decreased to 253.2/m^2. From the data given in Table 3.1 and 3.2 it is clear that crop density is much less than the total weed density at all the stages of crop growth. Dense population of Cyperus rotundus and Vicia hirsuta is mainly responsible for such high values of total weed density.

Further it is observed that not all the species of weeds are found throughout the growth of crop and thus the intensity of competition offered by weeds to crop also varies.

A comparison of Tables 3.1 and 3.2 shows that weed density is higher in the field plot of Aata Agriculture Farm as compared to the other site. This may be perhaps due to higher nutrient status of the soils of the latter area.

Table 3.1 : Density per square metre and frequency of wheat and weeds in a mixed stand of wheat (in Aata Agricultural Farm, Orai)

Species	Density			Frequency		
	Jan.	Feb.	March	Jan.	Feb.	March
Wheat	80.0	80.0	80.0	100.	100	100
Anagallis arvensis	32.8	56.6	25.8	40	70	30
Asphodelus tenuifolius	22.5	12.3	14.6	10	10	10
Cyperus rotundus	42.0	108.4	91.5	100	100	100
Cynodon dactylon	3.4	2.8	1.4	30	20	20
Demodium triflorum	2.4	3.8	1.2	10	20	10
Dichanthim annulatum	3.2	4.6	-	40	10	-
Euphorbia dracanculoides	-	1.4	-	-	10	-
Evolvulus alsinoides	85.6	94.2	84.2	90	80	100
Vicia hirsuta	40.8	79.2	34.5	90	100	100
Total	312.7	443.3	333.2			
Total weed density	232.7	363.3	253.2			

Table 3.2 : Density per square metre and frequency of wheat in a weeds infested field (situated outside the Aata Agriculture Farm, Orai)

Species	Density			Frequency		
	Jan.	Feb.	March	Jan.	Feb.	March
Wheat	82.4	74.2	80.2	100	100	100
Anagallis arvensis	-	28.4	32.6	-	30	30
Asphodelus tenuifolius	18.2	24.2	8.8	20	40	10
Chenopodium album	22.4	16.5	18.6	20	10	20
Convolvulus arvensis	10.6	24.8	22.6	30	20	30
Cynodon dactylon	25.4	38.4	32.4	50	60	30
Cyperus rotundus	42.5	68.5	35.2	50	70	100
Euphorbia dracunculoides	12.5	-	14.6	10	-	10
Evolvulus alsinoides	41.8	52.8	46.5	20	60	70
Vicia hirsuta	30.4	42.6	12.4	70	100	50
Total	286.0	370.3	303.9			
Total weed density	203.6	296.1	223.7			

CHAPTER IV

PRODUCTIVE STRUCTURE OF A PURE AND MIXED STANDS OF WHEAT

PRODUCTIVE STRUCTURE OF PURE AND MIXED STAND OF WHEAT

INTRODUCTION

Radiant solar energy is the only form of energy which the green plants can utilized for the production of complex organic compounds. At present when the world population is increasing at a rapid rate the most critical problem before the scientists is to increase the net primary production on which all organisms depend for their energy and food. The efficiency of different plant species with which they utilize solar energy is of great importance in determining their yield and thus a better understanding of the community architecture and light relatios in plant communities may help in the Problem of supporting an expanding world population Saeki, 1963 and Loomis et al, 1967.

Profile distribution of biomass and its relation to the amount of chlorophyll, photosynthetic area, moisture content and light penetration at different depths in the canopy indeed control the productivity to a large extent. Information on the distribution of light within a plant community permits one to estimate the photosynthesis that should occur. In this way importance of variations in canopy structure can be evaluated (Loomis et al. 1967) Advances during recent years have focussed attention on light distribution within the crop as the major determinant of the changing petter

of dry matter production of crops during ontogeny (Osman, 1971; Watson, 1952; Monsi and Saeki, 1953; Davidson and Phillip, 1956; Donald 1961, 63; Evanse, 1963; Monteith, 1965; San Pietro Greer and Army, 1967 and Eckardt, 1958). Yield of plants ultimately depends upon the efficiency of the photosynthetic process and upon the extent of the photosynthetic surface (Watson, 1952) Growth analysis and light interception studies have shown that as the leaf area index increases both light interception and crop dry weight increase (Schibles and Weber, 1965) : Monsi and Saeki (1953) obtained the vertical distributions of leaf area index and the associated illumination profiles in a large number of forest and herbaceous communities and on the basis of their investigations concluded that a thick development of foliage in a plant community results in a decrease of photosynthetic efficiency. Johnke et al. (1965) have shown that thickness, glometric configuration and chlorophyll content of the photosynthetic portion of vegetation per unit area of earth's surface and light intensity incident on surface at right angles to sun's rays should be measured and described as basic data in primary productivity studies. Pierce et al. (1967 a, b), Johnke et al. (1965), Newton et al. (1970), Loomis et al. (1967) have collected valuable information on the attenuation of light as a function of depth in the canopy.

In most of the species, specially in dicots leaf is the only component taking part in the photosynthesis and therefore, measurement of the area

of leaves is important. The ratio of the leaf area to the land area was termed as "leaf area index" by watson (1952). However, in many grasses, forbs and crops besides leaves, stem and inflorescence also contain chlorophyll and contribute significantly to dry matter production. Various workers have estimated the contribution of different components of wheat by their photosynthetic activity to the total dry weight of grains (Archbold, 1942; Enyi, 1962; Quinlan and Sagur, 1965; Voldeng and Simpson, 1967; Asana and Mani, 1950 and Throne, 1962).

Amount of chlorophyll per unit area has been used as an indicator of food assmilation potential of primary producers (Odum, McConell and Abott, 1958). Newbould (1969) states that while there is no suggestion that the amount of chlorophyll limits production still it represents one measure of the size of the photosynthetic system.

Taking into consideration the importance of structure plant communities, in the present investigation productive structures of pure and mixed stands of wheat crop have been studied to find out the effect of weed interference on the productive structure of wheat. Data on the amount of biomass, water, chlorophyll, light and photosynthetic area index in various vertical profiles of crop have been obtained.

METHODS

MEASUREMENT OF DRY MATTER PRODUCTION

Harvest method (Odum, 1960) was used to determine the net dry matter production of crop. Three quadrats of 25 X 25 sqs cm were thrown in the field at random. Monoliths were taken out upto 30 cm depth. After washing with water, roots were separated. Above ground parts were clipped at every 20 cm stratum. In each stratum all the green and non-green parts (leaves, stem, ear) were reparated and their fresh and dry weights (after drying at 80^0C in an oven for 48 hrs) were taken and calculated g/sq metre area. Sampling was done at vegetative (35 days), flowering (70 dsys), and fruiting (105 days) stages. The total dry weight at any time represented the standing crop biomass at that stage. From these values the standing biomass, productivity of the crop was calculated.

WATER CONTENT

Water content of all green and non-green components (leaf, stem, ear and root) was obtained by substracting the dry weights from their respective fresh weights and calculated as percentage on dry weight basis.

PHOTOSYNTHETIC AREA AND PHOTOSYNTHETIC AREA INDEX (Pho. A.I.)

Photosynthetic area of wheat is the total sum of the area of green

leaves, stem and ears. The ratio of this total photosynthetic area and the ground area which it occupies represents the photosynthetic area index.

For calculating the leaf area of wheat the value of constant factor (K) was calculated by the method described by kemp (1960). The outline of leaves was traced on a sheet of paper and their length (L) and breadth (B) were measured and further total area of leaf was measured by planimeter. The constant (K) was derived by following formula ;

$$L \times B \times K = \text{Area (measured by planimeter) of leaf}$$

$$K = \frac{\text{Area of leaf}}{L \times B}$$

The value of K for wheat was found to be 0.90.

For evaluating half area of weed species instead of calculating K value for each spcies, leaves were traced and that their area was directly measured with the help of planimeter.

Area of green stem of wheat was calculated by the formula "$2\pi rh$" (where r = radius of stem and h = length in cm).

The area of the ear was calculated by the method described by Dwivedi (1970). The constant factor K was found to be 0.85 for wheat.

All the constants were calculated by taking 25 replicates. Photosynthetic area of wheat and weeds at three stages of growth i.e. vegetative, flowering and fruiting were calculated for the each stratum.

CHLOROPHYLL CONTENT

Besides leaves, green stem and year to wheat also contribute enough in photosynthesis, their, chlorophyll content of these components in various profiles has been estimated.

Six samples of 20 leaf segments of 1 X 1 cm. 20 stem segments of one cm. length and with uniform diameter and ear equal fresh weight were taken. Three samples were weighed for fresh weight determinations and then kept in an oven at 80^{0}C for determination of dry weight. The other three samples were used for estimation of chlorophyll, each sample was kept in 80 percent acetone for 24 hrs in a refrigerator. After this treatment samples were taken out and shaked in a horizontal shaker. The volume of the solutions was made upto 25 ml. and optical density at 663 nm and 645 nm was taken in a Beckmann's spectrophotometer. Concentration of chlorophyll (a and b) was calculated by the method described by wood and Bachelord (1969). Chlorophyll content was also calculated on land area basis (g/sq. metre) by multiplying the value of mg/g dry weight to the dry weight per sq. metre area.

RESULTS

STANDING CROP BIOMASS AND RATE OF DRY MATTER PRODUCTION

There was an increase in the total standing crop biomass from

vegetative to fruiting stage linearly in pure and mixed stands. However, there was a significant decrease in the aboveground as well as underground biomass of wheat in mixed stand as compared to pure stand from vegetative period itself to the time of maturity (Table 4.1). Considering the biomass of different component parts of wheat it was observed that there was no significant difference in the biomass of green stem in two stands at vegetative stage but the biomass of leaves, non-green stem and roots of wheat decreased considerably in mixed stand in later stages of growth. There was significant variation in biomass of the components of wheat (leaf, stem, ear and root) in mixed stand at all depths in the canopy. It was also noticed that production of above-ground parts was more affected in lower stratum (0-20 cm and 20-40 cm) perhaps due to luxurious growth of weeds. Total aboveground biomass of wheat was found to be extremely concentrated either in the lowest stratum (0-20 cm.) at all stages of growth, which is due to heavy tillering at base, or at the uppermost stratification which is due to the presence of ears at the top.

It is evident from Table 4.2 that the biomass of wheat leaves increased upto 60 cm and then decreased in higher stratifications in pure and mixed stands. On the other hand biomass of stem decreased linearly from base to top layers. Biomass of ears was found to be maximum at the top most stratum in both stands. Table 4.3 indicates that total biomass of weeds was found to be maximum at the vegetative stage of crop then it

Table 4.1 : Dry matter production of various components of wheat in pure and mixed stands of wheat

Stage (days)	Stand	Stem		Leaves		Ears		Total above ground	Root	Total
		Green	Non-green	Green	Non-green	Green	Non-green			
35	PS	24.16	8.75	39.52	–	–	–	72.43	30.35	102.78
	MS	18.28	5.29	29.12	–	–	–	52.69	24.24	76.93
70	PS	549.12	140.71	226.24	53.06	218.72	–	1187.85	332.47	1520.31
	MS	428.80	98.25	146.86	32.58	144.32	–	850.81	302.52	1153.33
105	PS	634.56	186.90	122.24	99.79	726.56	180.92	1900.97	570.42	2471.39
	MS	483.20	131.56	100.49	76.93	576.23	80.38	1448.79	456.32	1905.11

Table 4.2 : Stratified distribution of oven dry biomass (g/m^2) of various components of wheat in pure and mixed stands of wheat

Stage	Height (cm)	Stand	Photosynthetic Parts				Non-photosynthetic parts				Total above Ground	Root (0-30 Cm)	Total
			Leaf	Stem	Ear	Total	Leaf	Stem	Ear	Total			
Vegetative	0-20	PS	39.52	24.16	–	63.68	–	8.75	–	8.75	72.43	30.35	102.78
		MS	29.12`	18.28	–	47.40	–	5.29	–	5.29	52.69	24.24	76.93
		't' value	**17.19***	**2.35**				**5.28***				**5.05***	
Flowering	0-20	PS	48.32	234.08	–	282.40	23.25	79.85	–	103.10	385.50	332.46	1520.31
		MS	38.16	183.04	–	221.20	11.71	60.21	–	–	71.72	293.12	302.52
		't' value	**4.84***	**19.33***			**25.64**	**18.52***				**5.12***	
	20-40	PS	64.48	168.16	–	232.64	22.45	56.21	–	78.66	311.30		
		MS	34.92	136.64	–	176.56	18.62	35.72	–	54.34	230.00		
		't' value	**4.81***	**2.15**			**1.40**	**7.36***					
	40-60	PS	67.04	118.40	26.88	212.32	7.36	4.65	–	12.01	224.33		
		MS	37.02	93.76	16.16	146.94	2.25	2.32	–	4.57	151.51		
		't' value	**4.41***	**4.70***	**5.17***		**13.81***	**1.34**					
	60-80	PS	46.40	28.48	191.84	266.72	–	–	–	–	266.72		
		MS	31.76	15.36	128.16	176.28	–	–	–	–	175.28		
		't' value	**4.44***	**4.54***	**5.18***								
Fruiting	0-20	PS	34.24	236.16	–	270.40	31.45	82.61	–	114.06	384.46	570.42	2474.39
		MS	27.21	164.32	–	191.53	22.36	64.25	–	86.61	278.14	456.42	1905.11
		't' value	**1.21**	**4.84***			**15.15***	**5.24***				**5.09***	
	20-40	PS	27.04	196.16	–	223.20	25.49	58.35	–	83.84	307.04		
		MS	28.64	155.36	–	184.00	22.41	32.69	–	55.10	239.10		
		't' value	**0.17**	**5.25***			**8.19***	**13.50***					
	40-60	PS	40.80	144.32	3.52	188.64	26.28	32.25	14.25	72.78	261.42		
		MS	35.84	116.00	2.32	154.16	21.35	26.38	8.43	56.16	210.32		
		't' value	**0.21**	**4.86***	**1.76**		**7.46***	**7.76***	**4.46***				
	60-80	PS	18.40	51.36	313.76	383.52	14.26	12.43	54.25	80.95	464.47		
		MS	8.00	43.04	229.44	280.48	9.45	6.89	32.49	48.83	329.31		
		't' value	**5.95***	**2.98**	**6.43***		**4.74***	**5.12***	**7.83***				
	80-100	PS	1.76	6.56	409.28	417.60	2.31	4.26	62.41	68.98	486.58		
		MS	0.80	4.48	344.47	349.75	1.36	1.35	39.46	42.17	391.92		
		't' value	**0.91**	**0.74**	**5.71***		**2.21**	**1.81**	**6.51***				

decreased at flowering and again increased at fruiting stage. However, total aboveground biomass increased linearly from vegetative to fruiting stage 20.76 g/m^2 to 70.49 g/m^2 respectively. The biomass of weeds was found to be accumulated more in the underground parts as compared to aboveground parts.

The rate of dry matter production of wheat increased from vegetative to flowering 102.78 and 76.93 g/m^2/35 days to 1417.53 and 1076.40 g/m^2/35 days in pure and mixed stands of wheat respectively. However at fruiting stage rate of production decreased.

Considerably to 951.08 and 751.78 g/m^2/35 days in pure and mixed stands respectively. From the above-mentioned data it is evident that rate of dry matter production of wheat was found to be reduced by about 25 percent in mixed stand as compared to pure stand (Table 4.4).

Table 4.3 : Oven dry biomass of weeds (g/m^2) in a mixed stand of wheat

Stage	Height	Aboveground biomass			Root	Total
	(cm)	Leaf	Stem	Total		
Vegetative	0-20	5.12	15.64	20.76	364.21	384.97
Flowering	0-20	12.48	13.12	25.60	174.88	200.48
Fruiting	0-20	34.24	36.25	70.49	215.36	285.85

Table 4.4 : Rate of dry matter production of various components of wheat in pure and mixed stand of wheat

Stage	Stand	Rate of production (g/m²/35 days)					Rate of dry matter production (d/m²/day)				
(days)		Green	Non-green	Total	Root	Total	Green	Non-green	Total	Root	Total
35	PS	63.68	8.75	72.43	30.35	102.78	1.819	0.250	2.069	0.867	2.936
	MS	47.40	5.29	52.69	24.24	76.93	1.354	0.151	1.505	0.692	2.198
70	PS	930.40	185.02	1115.42	302.11	1417.53	26.582	5.286	31.850	8.631	40.500
	MS	672.58	125.54	798.12	278.28	1076.40	19.216	3.586	22.803	7.950	31.640
105	PS	552.96	232.59	173.12	237.96	951.08	15.798	6.645	20.374	6.798	21.173
	MS	487.34	163.33	597.98	153.80	751.78	13.924	4.666	17.085	4.394	21.479

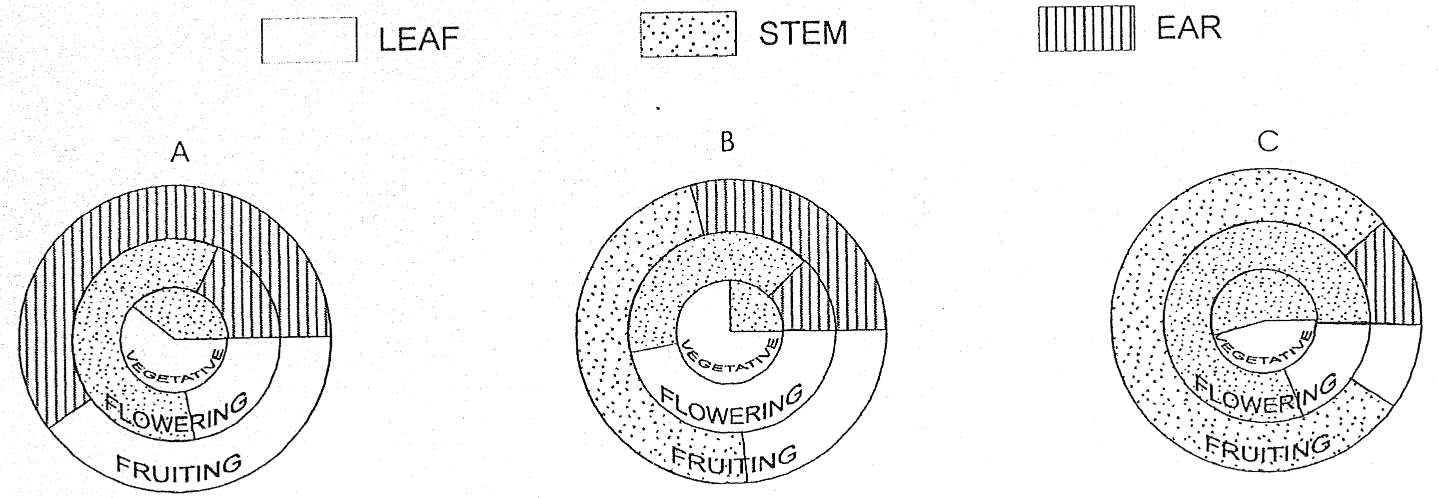
PERCENTAGE CONTRIBUTION OF COMPONENTS OF WHEAT TO TOTAL BIOMASS

The percentage of the total biomass of leaves, stems and ears to total dry weight it was found that contribution of various components to total dry matter production differs considerably for successive stages of growth. At vegetative stage the contribution of green leaves to total photosynthetic biomass is maximum of 62.13 percent and 61.43 in PS and MS, which is followed by stem at flowering (75.83 percent and 59.55 percent in PS and MS) and ears at fruiting stage (48.98 and 55.65 percent in PS and MS respectively). In mixed stand percentage contribution of green leaves to total photosynthetic biomass was considerably reduced while contribution of ears increased (Table 4.12 and Fig. 4.1)

WATER CONTENT

Distribution of percentage water content in various profiles of green and non-green components of wheat plant such as leaves, stems and ears shows that water content increased in the upper layers and maximum percentages of water was found in all components of uppermost strata. The percentage water content of all components of wheat (leaves, stem ear and root) decreased with increasing age both in pure stand and mixed stand. A comparison of percentage water content of wheat in pure and mixed stands showed that water content was significantly less in mixed stand as

Fig.4.1: Percentage contribution of leaf, stem and ear in A. photosynthetic biomass, B. total chlorophyll content sq. metre and C. Pho.A.I. of pure stand (above) and mixed stand (below).


LEAF
STEM
EAR
A
B
C
VEGETATIVE
FLOWERING
FRUITING

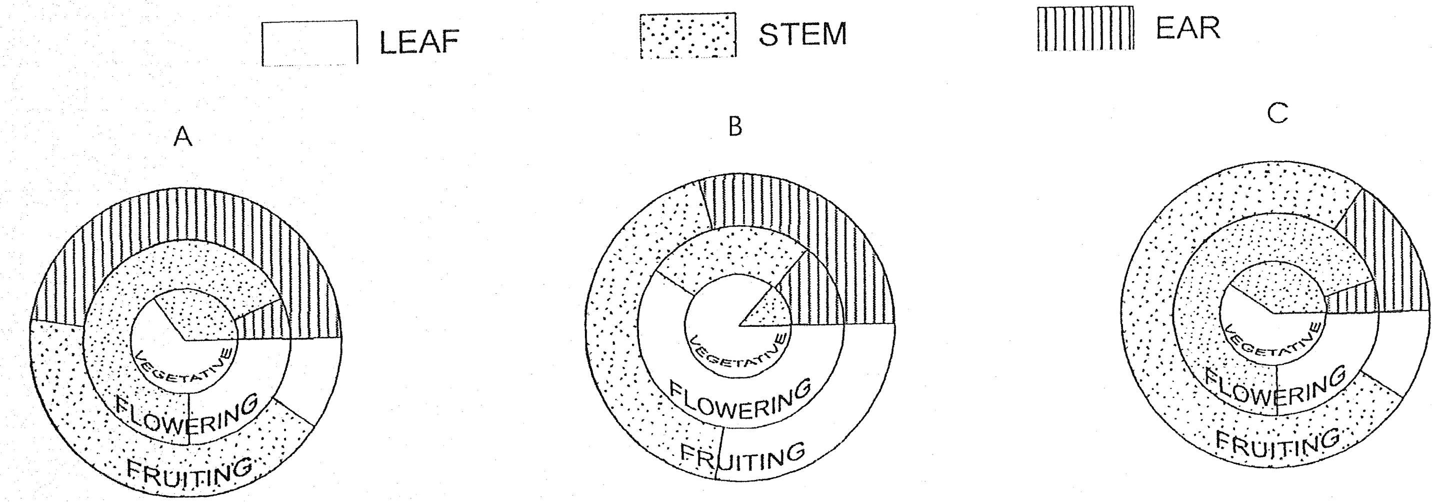

LEAF
STEM
EAR
A
B
C
VEGETATIVE
FLOWERING
FRUITING

Table 4.5 : Stratal variations in percentage water content of different components of wheat in pure and mixed stands

Stage	Height (cm)	Stand	Photosynthesis parts			Non-photosynthetic parts			
			Leaf	Stem	Ear	Leaf	Stem	Ear	Root
Vegetative	0-20	PS	97.97	94.83	–	–	28.14	–	94.58
		MS	92.06	95.45	–	–	27.07	–	90.03
		't' Value	**2.35**	**2.11**	–	–	**1.15**	–	**1.86**
Flowering	0-20	PS	57.01	54.23	–	9.82	11.80	–	92.44
		MS	43.35	40.17	–	9.03	9.24	–	85.72
		't' Value	**4.96***	**4.98***	–	**0.91**	**1.22**	–	**55.21***
	20-40	PS	75.97	72.96	–	14.65	15.76	–	–
		MS	62.21	59.21	–	13.51	15.26	–	–
		't' Value	**5.26***	**4.93***	–	1.43	**0.72**	–	–
	40-60	PS	86.45	82.17	74.23	20.64	26.95	–	–
		MS	70.88	70.54	65.26	14.98	21.04	–	–
		't' Value	**4.41***	**5.12***	**5.21***	**5.21***	**4.92***	–	–
	60-80	PS	96.47	88.96	93.54	–	–	–	–
		MS	70.22	61.49	73.44	–	–	–	–
		't' Value	**7.19***	**4.56***	**5.21***	–	–	–	–
Fruiting	0-20	PS	16.86	9.92	–	6.87	6.22	–	60.16
		MS	13.66	8.84	–	3.39	4.88	–	52.37
		't' Value	**5.21***	**1.24**	–	**2.31**	**2.46**	–	**4.98***
	20-40	PS	36.67	22.79	–	7.10	6.69	–	–
		MS	34.28	18.04	–	4.58	5.77	–	–
		't' Value	**1.34**	**1.81**	–	**2.85**	**1.86**	–	–
	40-60	PS	61.03	38.81	18.75	9.09	9.35	7.09	–
		MS	57.05	31.42	16.96	6.31	7.25	6.19	–
		't' Value	**4.83***	**2.98**	**1.36**	**5.12**	**2.18**	**1.21**	–
	60-80	PS	82.89	57.90	26.27	11.26	10.03	9.26	–
		MS	73.75	52.38	20.70	8.66	8.32	8.26	–
		't' Value	**3.91**	**3.96**	**2.98**	**4.92***	**2.83**	**1.98**	–
	80-100	PS	93.96	74.99	27.65	14.02	11.78	11.39	–
		MS	83.43	52.38	23.68	12.64	9.96	9.67	–
		't' Value	**5.24***	**6.76***	**3.45**	**3.42**	**2.98**	**2.21**	–

* Significant at 5% level.

compared to values found in pure stand (Table 4.5). Water content was found to be maximum in green leaves of wheat at all stages of growth as compared to stem and ear.

Percentage water content of weeds increased from vegetative to flowering stage but at fruiting stage it declined when the weeds were found in dried condition. In weeds also percentage of water was maximum in leaves (Table 4.6).

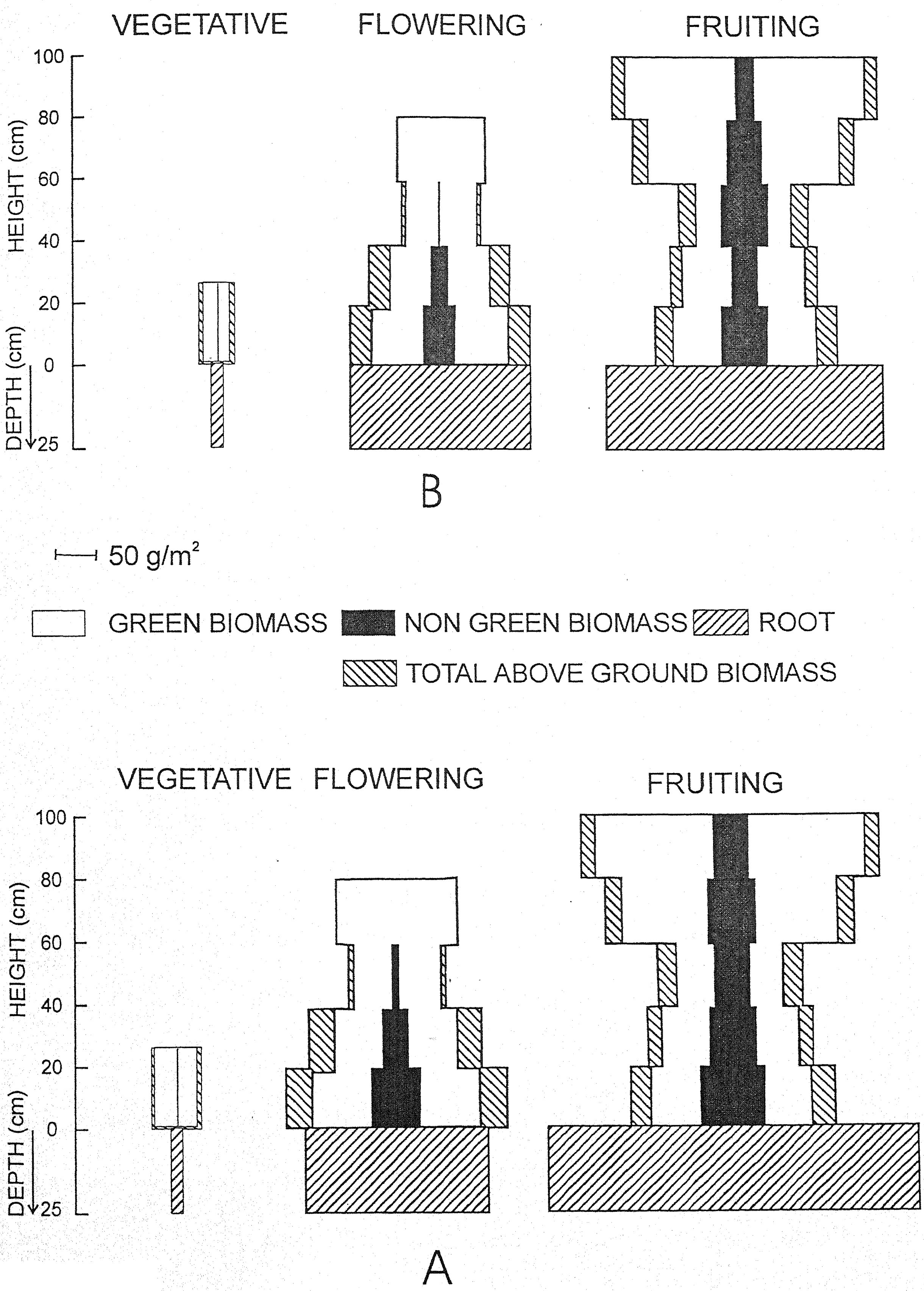
PHOTOSYNTHETIC AREA AND PHOTOSYNTHETIC AREA INDEX

Distribution of photosynthetic area index in different profiles of wheat well resembles that of photosynthetic biomass (Fig. 4.2) of wheat in pure and mixed stands. As the photosynthetic biomass of wheat increases, photosynthetic area index also increased and vice-versa at all stages of development.

Table 4.6 : Variations in percentage water content of different components of weeds

Stage	Height (cm)	Leaf	Stem	Root
Vegetative	0-20	86.45	72.93	88.31
Flowering	0-20	74.26	72.21	76.43
Fruiting	0-20	18.22	15.36	15.98

Fig.4.2: Vertical distribution of oven dry diomass of wheat (g/m^2) in pure stand (A) and mixed Stand (B).



VEGETATIVE
FLOWERING
FRUITING
HEIGHT (cm)
DEPTH (cm)
100
80
60
40
20
0
25
B
50 g/m²
GREEN BIOMASS
NON GREEN BIOMASS
ROOT
TOTAL ABOVE GROUND BIOMASS
VEGETATIVE
FLOWERING
FRUITING
HEIGHT (cm)
DEPTH (cm)
100
80
60
40
20
0
25
A

A significant difference in the photosynthetic area of all components of wheat in pure and mixed stands from vegetative stage to fruiting stage of growth is obtained. The photosynthetic area of wheat/sq. metre in pure stand and mixed stands was found to be 8895.08 and 6560.49 sq. cm. at the age of 35 days, which increased upto a maximum value of 125196.45 and 93911.32 sq.cm/m^2 at the age of 70 days in pure stand and mixed stand respectively. However, at fruiting stage due to senescence of older parts of the stem and leaves photosynthetic area became reduced to 72456.89 and 49083.24 sq.cm./m^2 in pure stand and mixed stand respectively. From Table 4.7 it is evident that Pho. A. I. of wheat increased from vegetative to flowering stage from 0.88 and 0.65 to 12.51 and 9.39 in pure stand and mixed stands respectively, and then after flowering decreased to 7.24 and 4.90 in both stands.

Photosynthetic area of weeds was noted to be maximum at the age of 70 days of crop age 3769.98 sq.cm/m^2. However at 105 days age of crop due to the senescence, all weeds became non-green and therefore, photosynthetic area and thus the Pho. A. I. was reduced to zero (Table 4.7).

LIGHT PENETRATION AND CHLOROPHYLL CONTENT

There was an inverse relationship between Pho. A.I. and light penetration. Therefore as the Pho. A. I. of wheat increased, light penetration decreased in pure as well as mixed stands (Fig 4.3). At vegetative stage

Fig.4.3: Vertical distribution of photosynthetic area index and light intensity at different depths in the canopy in A. pure stand and B. mixed stand.

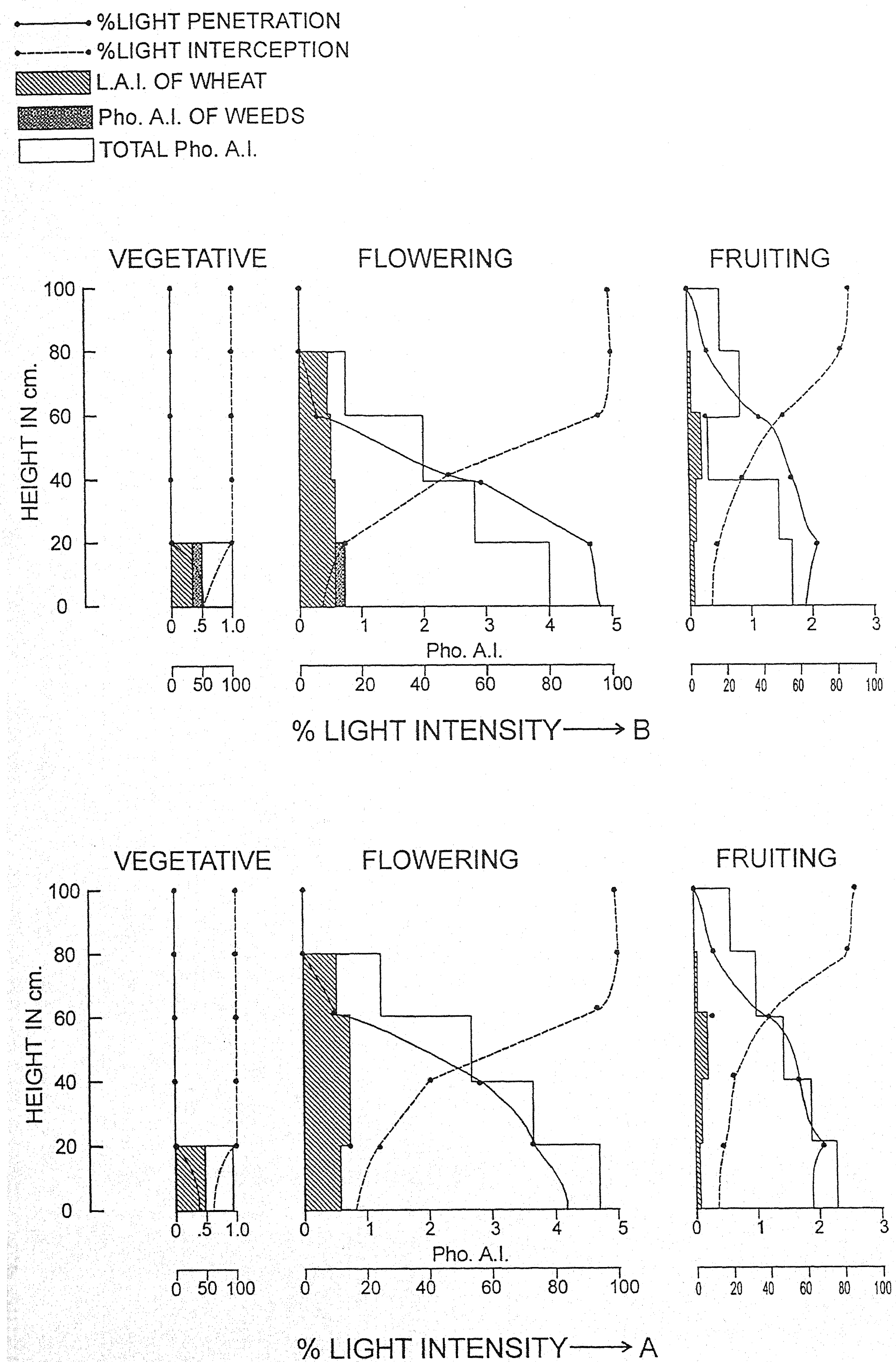

%LIGHT PENETRATION
%LIGHT INTERCEPTION
L.A.I. OF WHEAT
Pho. A.I. OF WEEDS
TOTAL Pho. A.I.
VEGETATIVE
FLOWERING
FRUITING
HEIGHT IN cm.
100
80
60
40
20
0
0 .5 1.0
0 1 2 3 4 5
0 1 2 3
Pho. A.I.
0 50 100
0 20 40 60 80 100
0 20 40 60 80 100
% LIGHT INTENSITY → B
VEGETATIVE
FLOWERING
FRUITING
HEIGHT IN cm.
100
80
60
40
20
0
0 .5 1.0
0 1 2 3 4 5
0 1 2 3
Pho. A.I.
0 50 100
0 20 40 60 80 100
0 20 40 60 80 100
% LIGHT INTENSITY → A

Table 4.7 : Stratified distribution of photosynthetic area index of wheat and weeds in pure and mixed stands of wheat

Stage	Height (cm)	Pure Stand				Mixed Stand							Total Wheat + Weeds
		Wheat				Wheat				Weeds			
		Leaf	Stem	Ear	Total	Leaf	Stem	Ear	Total	Leaf	Stem	Total	
Vegetative	0-20	0.47	0.41	–	0.88	0.34	0.31	–	0.65	0.06	0.27	0.33	0.98
Flowering	0-20	0.57	3.95	–	4.52	0.45	3.17	–	3.62	0.14	0.22	0.36	
	20-40	0.77	2.91	–	3.68	0.47	2.36	–	2.83	–	–	–	9.56
	40-60	0.80	2.05	0.03	2.89	0.44	1.62	0.02	2.04	–	–	–	
	60-80	0.55	0.49	0.26	1.31	0.38	0.26	0.07	0.71	–	–	–	
Fruiting	0-20	0.20	2.04	–	2.25	0.16	1.42	–	1.58	–	–	–	
	20-40	0.16	1.69	–	1.85	0.17	1.34	–	1.51	–	–	–	
	40-60	0.24	1.24	–	1.43	0.21	0.10	0.01	0.32	–	–	–	4.55
	60-80	0.11	0.44	0.53	1.08	0.05	0.37	0.48	0.59	–	–	–	
	80-100	0.01	0.05	0.57	0.63	–	0.03	0.52	0.55	–	–	–	

when total Pho. A. I. (wheat and weeds) was 0.88 and 0.99, light penetration was found to be 65 and 50 percent in PS and MS respectively. Reduction in the percentage light penetration is MS over PS was obviously due to presence of weeds. At flowering stage when Pho. A. I. of wheat attained its maximum value in both stands light penetration at ground surface under the crop was lowest i.e., 15 and 5 percent in PS and MS respectively. Table 4.8 shows that percentage light penetration decreases considerably towards the base of crop commmunity.

There was only slight variation in total chlorophyll content at different depths in the canopy at all stages of growth as compared to vertical distribution of photosynthetic biomass and Pho. A. I. However, an exception was in the case of stem where the amount of chlorophyll increased towards top whereas both the biomass and area of green stem decreased towards top and was maximum at lowest levels. This is due to higher concentration of chlorophyll per gram of dry matter in stems (Tables 4.9).

Chlorophyll concentration (a and b) mg/g varied significantly. It was lower in mixed stand as compared to pure stand in all components throughout the growing season of the crop and thus the variation in chlorophyll content mg/m^2 was noticed in two stands. Concentration of chlorophylls (mg/g dry wt.) increased with increasing height in leaves, stem and ear of wheat that is concentration was more in young leaves and stem as compared to older parts in both stands. However, there was not much

Table 4.8 : Percentage light penetration and percentage light interception in pure and mixed stands of wheat

Stage	Height (cm)	Stand	Percentage light penetration	Percentage light interception
	0	PS	65	35
Vegetative		MS	50	50
(35 days)	20	PS	100	0
		MS	100	0
	0	PS	15	85
		MS	5	95
	20	PS	25	75
		MS	12	88
	40	PS	40	60
Flowering		MS	45	55
(70 days)	60	PS	90	10
		MS	96	4
	80	PS	100	0
		MS	100	0
	100	PS	100	0
		MS	100	0
	0	PS	20	80
		MS	15	85
	20	PS	21	79
		MS	20	80
	40	PS	26	74
Fruiting		MS	32	68
(105 days)	60	PS	45	55
		MS	54	46
	80	PS	90	10
		MS	90	10
	100	PS	100	0
		MS	100	0

Table 4.9 : Stratal variations in chlorophyll content (mg/ m^2) of wheat in a pure and mixed stands of wheat

Stage	Height (cm)	Plant Part	Pure Stand			Mixed Stand		
			Chlorophyll a	Chlorophyll b	Total Chlorophyll	Chlorophyll a	Chlorophyll b	Total Chlorophyll
Vegetative	0-20	Leaf	243.03	243.03	470.86	123.96	117.01	240.97
		Stem	37.59	26.87	64.46	67.01	85.09	152.10
Flowering	0-20	Leaf	371.80	377.99	749.79	284.66	301.25	585.91
		Stem	480.61	268.32	748.93	347.59	217.36	564.95
	20-40	Leaf	1091.31	413.31	1504.62	568.84	401.27	970.11
		Stem	674.43	433.55	1107.98	491.57	366.70	858.27
	40-60	Leaf	1199.94	878.76	2078.70	625.41	448.86	1074.27
		Stem	1808.73	707.93	2516.66	882.42	528.08	1410.50
		Ear	53.78	102.77	156.55	27.17	59.08	80.25
	60-80	Leaf	996.06	638.39	1634.55	618.20	405.32	1023.52
		Stem	343.19	200.45	543.64	174.32	112.56	286.88
		Ear	641.55	568.86	1210.41	428.61	357.95	786.56
Fruting	0-20	Leaf	220.23	199.44	419.67	141.84	116.61	258.45
		Stem	359.45	630.75	990.20	194.30	185.27	379.57
	20-40	Leaf	400.89	250.30	651.19	357.45	179.71	537.16
		Stem	578.77	499.93	1078.70	359.73	357.17	716.90
	40-60	Leaf	687.84	726.94	1414.78	509.46	436.81	946.27
		Stem	1411.37	783.93	2195.30	1016.97	532.09	1549.06
		Ear	7.40	13.95	21.35	3.81	6.43	10.24
	60-80	Leaf	339.59	252.88	592.47	121.56	82.00	203.56
		Stem	525.54	347.14	872.68	384.67	223.70	608.37
		Ear	1009.31	929.57	1938.88	626.71	562.35	1189.06
	80-100	Leaf	11.58	7.45	19.03	3.37	1.87	5.24
		Stem	19.42	22.17	41.59	11.28	12.98	24.26
		Ear	355.29	278.92	635.21	217.53	107.41	384.94

variation in the chlorophyll 'b' as compared to chlorophyll 'a' with height. Chlorophyll content mg/m^2 increased from vegetative to flowering stage (535.36 to 11978.99 in PS and 283.43 to 7647.22 mg/m^2 in MS) and again decreased at fruiting stage to 10751.52 and 7112.67 mg/m^2 in pure and mixed stand respectively. Amount of chlorophyll 'a' was 5983.84 and 3953.69 mg/m^2 in PS and MS respectively while amount of chlorophyll 'b' in PS was 4767.68 mg/m^2 and in MS was 7074.49 mg/m^2. Thus it is marked that amount of chlorophyll 'a' is more in pure stand while chlorophyll 'b' is more in mixed stand (Tables 4.10 and 4.11).

It is evident from the data presented in Table 4.12 that concentration of chlorophylls is comparatively high in weeds as compared to wheat but total chlorophyll content (mg/m^2) is only 232.85 and 271.29 mg/m^2 at vegetative and flowering stages of wheat as compared to considerably higher values for wheat mentioned above.

A positive correlation of chlorophyll content with rate of production, Pho. A. I. and water content of wheat at all growth stages was obtained (Fig. 4.5).

DISCUSSION

There is a significant variation in net dry matter production of wheat in pure stand and mixed stand from the vegetative stage to the time of harvesting which indicates the competitive effect of weeds on the

Table 4.10 :Stratified distribution of total chlorophyll on g/m^2 of various components of wheat in a pure and mixed stands of wheat

Stage	Height	Stand	Leaf	Stem	Ear	Total
Vegetative	0-20	PS	470.88	64.48	–	535.35
		MS	240.99	42.44	–	283.43
		't' Value	**13.98***	**5.12**		
Flowering	0-20	PS	749.80	748.96	–	1498.76
		MS	585.92	564.95	–	1150.87
		't' Value	**5.11***	**3.92**		
	20-40	PS	1504.64	1108.00	–	2612.64
		MS	970.11	1056.25	–	2026.37
		't' Value	**5.96***	**2.30**		
	40-60	PS	2078.72	1844.64	156.56	4079.92
		MS	1074.28	1410.50	86.25	2571.03
		't' Value	**4.93***	**5.93***	**4.41***	
	60-80	PS	1634.56	543.65	1210.43	3388.64
		MS	1023.52	210.09	786.56	2020.17
		't' Value	**5.09***	**4.87***	**5.08***	
Fruiting	0-20	PS	419.68	990.24	–	1409.92
		MS	258.56	379.57	–	638.13
		't' Value	**4.34***	**5.50**		
	20-40	PS	651.20	1078.72	–	1729.92
		MS	537.17	716.90	–	1254.07
		't' Value	**2.29**	**14.5***		
	40-60	PS	1414.80	2195.32	21.36	3631.48
		MS	946.28	1549.06	10.24	2505.58
		't' Value	**4.61***	**7.42***	**4.97***	
	60-80	PS	592.48	872.69	1938.88	3404.05
		MS	203.56	608.37	1189.07	2001.00
		't' Value	**4.31***	**5.58***	**7.99***	
	80-100	PS	19.04	41.60	634.20	694.84
		MS	5.24	24.27	362.59	392.10
		't' Value	**1.76**	**5.05***	**11.45***	

* Significant at 5% level.

Table 4.11 :Stratified distribution of chlorophyll a, b and total (mg/m^2) in a pure and mixed stands of wheat

Stage	Height (cm)	Pure Stand			Mixed Stand		
		Chlorophyll a	Chlorophyll b	Total Chlorophyll	Chlorophyll a	Chlorophyll b	Total chlorophyll
Vegetative	0-20	280.64	254.72	535.36	209.07	184.04	393.11
	Total	**280.64**	**254.72**	**535.36**	**209.07**	**184.04**	**393.11**
Flowering	0-20	851.40	647.36	1498.76	557.65	439.66	997.31
	20-40	1765.12	1147.42	2912.54	916.87	656.94	1572.81
	40-60	2389.62	1789.96	4179.58	1549.88	1084.30	2634.23
	60-80	1979.36	1408.75	3388.11	1025.67	747.43	1773.10
	Total	**6985.50**	**4993.49**	**11978.99**	**4050.07**	**2928.33**	**7647.22**
Fruiting	0-20	579.04	730.88	1309.92	335.60	636.04	971.64
	20-40	979.20	750.72	1729.72	716.30	1251.64	1967.94
	40-60	2171.20	1461.28	3632.48	1539.08	2532.71	4071.79
	60-80	1871.68	1512.64	3384.32	1459.83	2621.38	4081.21
	80-100	382.72	312.16	694.88	38.48	32.78	71.26
	Total	**5983.84**	**4767.68**	**10751.52**	**4089.29**	**7074.55**	**11163.84**

production of wheat. As the age advanced dry matter increased in both stands and attained the maximum value of 2474.39 and 1905.11 g/m^2 in pure and mixed stands. However, rate of dry matter production of wheat increased from vegetative to flowering stage (102.78 and 76.93 g/m^2/35 days to 1417.33 and 1076.40 g/m^2/35 days in PS and MS respectively) in both stands, but again decreased at fruiting stage to 951.08 and 751.78 g/m^2/35 days (Table 4.4). These differences in the dry matter production seem to be governed by the age of the crop. Besides dry matter production other parameters i.e., photosynthetic area index, water content, chlorophyll content, and light penetration at different depths in the canopy also show marked variations with ageing.

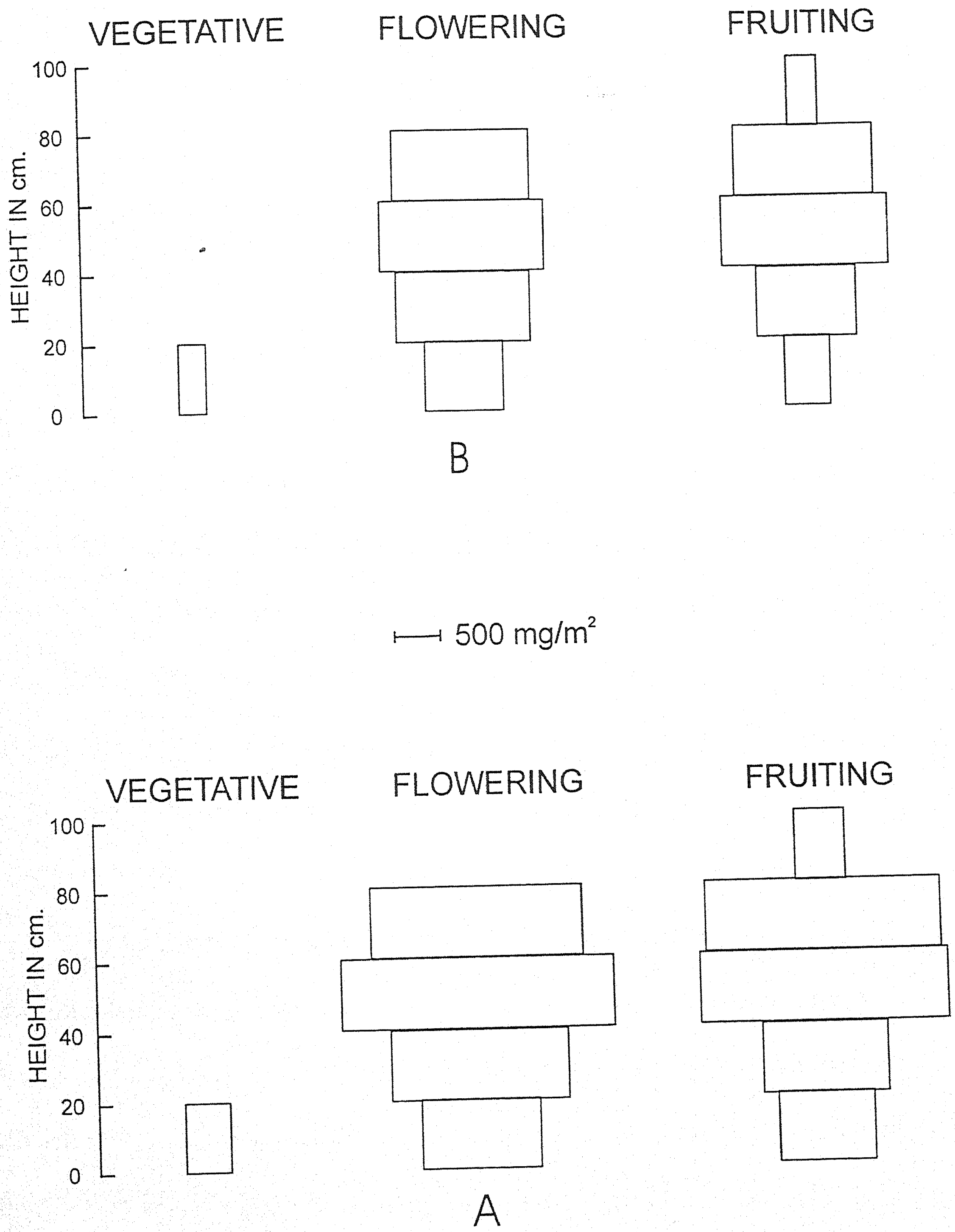
Considering the Pho. A. I. of wheat at different developmental stages in pure and mixed stands of wheat it was found that at the age of 70 days Pho. A.I. of green stem and ear was more in comparison to area of green leaves, however, percentage of water and at the same time chlorophyll concentration was comperatively low in stem and ear. The percentage contribution of stem and ears to the total chlorophyll and Pho. A. I. indirectly indicate their contribution to the total dry matter production of wheat (Table 4.12; Fig. 4.1). The data of Watson (1958), Brougham (1960), Wilfong et al (1967) and Dwivedi (1970) show that in different species as the leaf area index increases, light penetration decreases with a corresponding decrease in NAR while NAR is used as a measure of solar

Table 4.12 :Percentage contribution of various photosynthetic parts to the total photosynthetic biomass, total chlorophyll and protosynthetic area index in a pure and mixed stands of wheat

Stage	Stand	Biomass (%)			Chlorophyll (%)			Photosynthetic area index (%)		
		Leaf	Stem	Ear	Leaf	Stem	Ear	Leaf	Stem	Ear
Vegetative	PS	62.13	37.93	–	87.82	12.48	–	53.40	46.59	–
	MS	61.43	38.56	–	75.42	25.48	–	48.21	51.79	–
Flowering	PS	22.75	75.83	22.88	52.74	35.75	11.59	21.62	75.84	2.44
	MS	20.39	59.55	20.04	48.91	39.82	11.27	18.32	80.26	1.42
Fruiting	PS	8.24	42.17	48.98	26.57	47.38	26.04	10.08	75.82	13.50
	MS	8.26	39.72	55.65	23.26	49.46	27.28	9.06	80.41	10.53

energy conservation and dry matter production. In the present investigation too, it was found that as the light penetration decreases, the photosynthetic area index increases with a corresponding decrease in the rate of dry matter production. Watson (1958) has reported that maximum leaf area in both barley and wheat occurred during the phase of rapid shoot elongation, at a time when the shoots had reached about half their final height, but after ear emergence leaf area had fallen to about 2/3rd its maximal value. These observations are in support of the present findings that LAI as well as Pho. A. I. of wheat increase to a maximum value of 2.71 and 12.53 in PS and 1.73 and 9.20 in MS at the age of 70 days (flowering stage) when the rate of production is also maximum, but soon with the appearance of ears rate of production decrease and the LAI and Pho. A. I. also decreased to 0.73 and 7.24 in PS and 0.58 and 4.90 in MS respectively (Table 4.7). At 70 days age when Pho. A.I. of wheat attained its maximum value the light penetration at ground surface was minimum i.e., 20 and 15 percent in pure and mixed stand respectively (Fig. 4.3). Brougham (1960) stated that there was a significant correlation between LAI and the maximum growth rates of the different species. Pierce et al (1967) have shown that the manner in which light is distributed within a community may greatly influence dry matter production and this is affected mainly by leaf distributions pattern, leaf angle etc. (Warren Wilson, 1959; Isobe, 1962; Dewit, 1965; Anderson, 1966; Duncan et al, 1967; Monteith, 1965; Saeki, 1960 and Verhagen et

Fig.4.4: Vertical distribution of total chlorophyll content (mg/m^2) of wheat in pure stand (A) and mixed stand (B).


VEGETATIVE
FLOWERING
FRUITING
HEIGHT IN cm.
100
80
60
40
20
0
B
500 mg/m²
VEGETATIVE
FLOWERING
FRUITING
HEIGHT IN cm.
100
80
60
40
20
0
A

al, 1963). In the present study the data obtained show that rate of production has a positive correlation with LAI as well as Pho. A. I. at all stages of growth and at the same time LAI and Pho. A. I. have positive correlation with light interception. There was found a significant positive correlation between Pho. A. I. and green biomass and photosynthetic area and total chlorophyll content of wheat (Fig. 4.5)

At maturity due to fall in concentration of chlorophyll, reduction in the water content, and photosynthetic area, the rate of photosynthesis is reduced and consequently the rate of production also declines in wheat crop. Brougham (1960) obtained maximum positive correlation of chlorophyll content with photosynthetic activity. Das (1963) reported that green colour of the leaves decreases with increasing age followed by reduced NAR. Friend et al (1967) reported that absolute growth rate was maximum at the time of ear emergence but declines continuously with time in wheat. Thorne (1960) reported that NGR, NAR and leaf area fell with time at similar rate in potato, sugarbeet and barely, Watson (1952) describing the physiological basis of variation in yield of the crops and Woledge and Jewiss (1969) working on tall Festuca (Festuca arundinacea) reported that the rate of photosynthesis decreased with increasing age. In the present study at flowering stage (70 days) there was an increase in Pho. A. I., light interception, chlorophyll content and percentage water content of photosynthetic parts, but at fruiting stage (105 days), there was a reduction

Fig.4.5: Correlation between :

(A) Pho.A.I. and green biomass/m^2 of wheat leaf

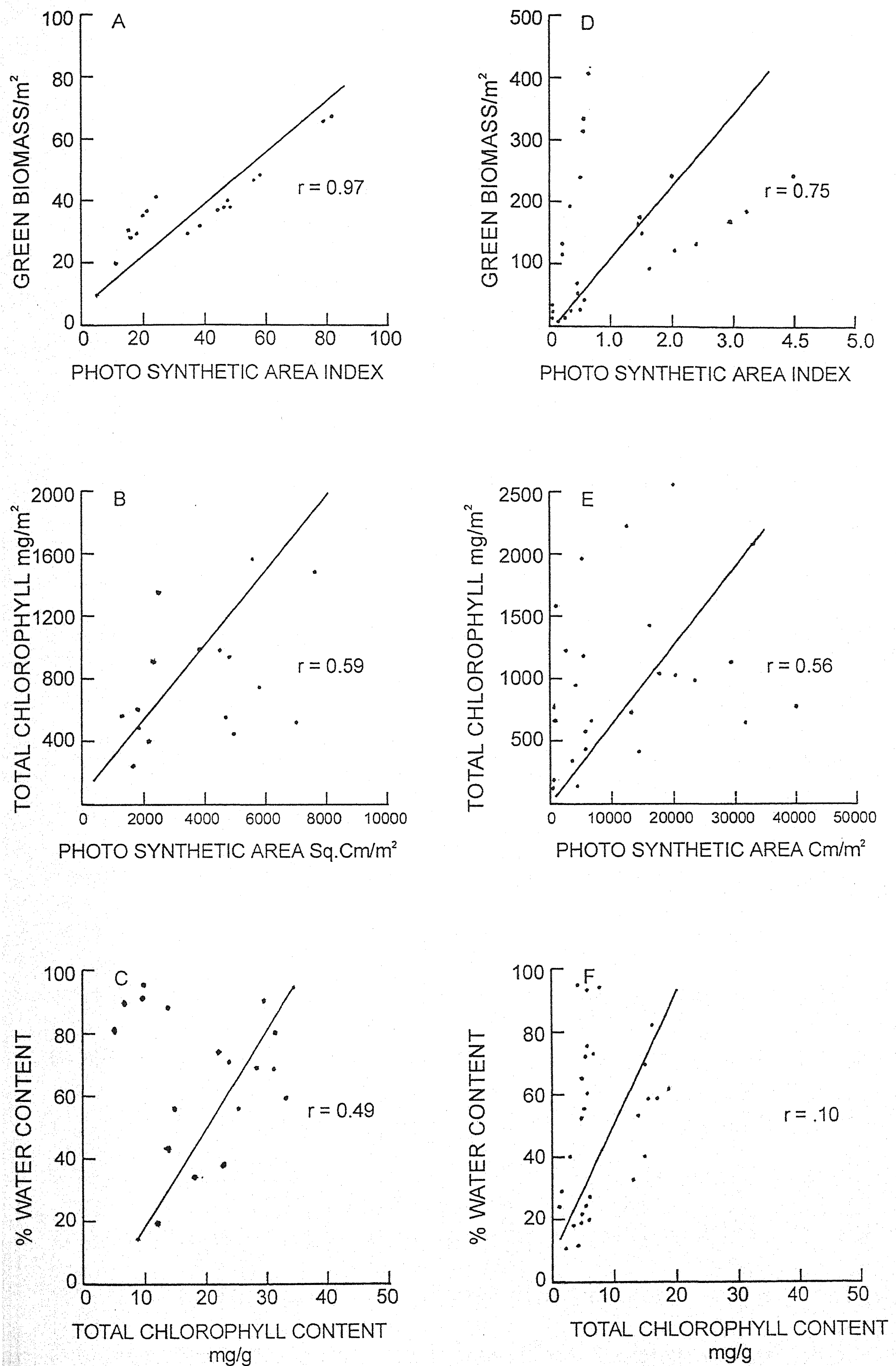
(B) Photosynthetic area sq.cm/sq.m^2 and total chlorophyll (mg/m^2) of wheat leaf

(C) Total chlorophyll content (mg/g) and water content (%) of wheat leaf

(D) Pho.A.I. and gree biomass (g/m^2) of wheat stem and ear

(E) Photosynthetic area sq.cm/m^2 and total chlorophyll mg/m^2 of wheat, stem and ear

(F) Total chlorophyll content mg/g and water content (%) of wheat, stem and ear.


A
GREEN BIOMASS/m²
PHOTO SYNTHETIC AREA INDEX
r = 0.97
D
GREEN BIOMASS/m²
PHOTO SYNTHETIC AREA INDEX
r = 0.75
B
TOTAL CHLOROPHYLL mg/m²
PHOTO SYNTHETIC AREA Sq.Cm/m²
r = 0.59
E
TOTAL CHLOROPHYLL mg/m²
PHOTO SYNTHETIC AREA Cm/m²
r = 0.56
C
% WATER CONTENT
TOTAL CHLOROPHYLL CONTENT mg/g
r = 0.49
F
% WATER CONTENT
TOTAL CHLOROPHYLL CONTENT mg/g
r = .10

in Pho. A. I. increase the penetration of light to lower strata and reduction in chlorophyll and water content.

On the basis of the observations Donald (1963) showed that in wheat and barley the maximum values of LAI (2.83) occur at the time of rapid shoot elongation but at ear emergence LAI had fallen down to half the peak value and at harvest it is zero. He has also shown that as the LAI increases beyond the optimum, the low light intensity at the base of the canopy and the weak photosynthesis of the lowest leaves lead not only to a negative contribution by these leaves but to a rapid loss in weight and eventually to their death. On the other hand Blackmann and Black (1959) have postulated that the vegetation in any region are in a dynamic equillibirium when there is the maximum exploitation of the incoming radiation to produce the greatest production of dry matter. Chlorophyll concentration increases from the bottom to the upper strata in wheat, which may be either due to the aging of lower portions (leaf and stem) of wheat of due to reduction in moisture content. A significant positive correlation between chlorophyll concentration and percentage water content has been obtained (Fig. 4.5) In PS and MS as the Pho. A. I. of wheat increased light interception increased and at 70 days age only 20 percent light could reach the surface in PS while at fruiting stage due to the senescence of older leaves and stem portions light interception decreased but howerver, this fall in Pho. A. I. of wheat from flowering to fruiting stage

was not followed by increase in the rate of dry matter production. On the other hand, in MS light interception was considerably less in the upper layers of the canopy as compared to PS because of comparatively less Pho. A. I. but at the lower stratum due to presence of weeds light penetration was reduced and only 5 and 15 percent of the light was available at the surface at flowering and fruiting stages respectively (Fig. 4.3).

Newbould (1969) states that while there is no suggestion that the amount of chlorophyll limits production, still it represents one measure of the size of the photosynthetic system. Bray (1960) has shown that there is positive correlation between chlorophyll content and dry matter production from the beginning of the vegetative period to the time of harvesting. From present data also it is evident that in wheat also there is not much difference in the amount of chlorophyll in various strata as compared to Pho. A. I. and dry matter production in both pure and mixed stands, except in case of stem whose chlorophyll content is less in lower strata contrary to dry weight production and Pho. A. I. of stem and increases towards upper levels. This may be due to degradation of chlorophyll in older portions of stem due to senescence.

The lower rate of production of wheat at all stages of growth in MS as compared to PS seems due to less availability of light to lower leaves due to shading effect by weeds. The present findings show that low rate of production of wheat in MS is associated with poor development of root

system and low water content, and this may decrease eventually Pho. A. I., chlorophyll content, phosphorus and nitrogen contents of photosynthetic parts, which all will surely reduce the net dry matter production of wheat in mixed stand as compared to the pure stands of wheat crop.

The accumulation of more biomass of weeds in underground portions at all stages of growth checks the growth of root system of wheat in MS and thus reduces the availability of water and nutrients to wheat, Therefore, it can be concluded that in MS aboveground competition due to weeds is not so severe as compared to root competition and while rate of production is influenced by the amount of chlorophyll, water and photosynthetic area of wheat in pure and mixed stands of wheat, interference by weeds is also significant in influencing the production of wheat in mixed stand and about 20 percent reduction in production is marked. These characters set place to the limits of production.

CHAPTER V

MINERAL STRUCTURE OF PURE AND MIXED STANDS OF WHEAT

MINERAL STRUCTURE OF PURE AND MIXED STANDS OF WHEAT

INTRODUCTION

Kramer and Kozlowaski (1960) stated that translocation of minerals to the top and organic compounds to the roots is as essential for growth of plants as their synthetic activities. Plants absorb minerals from soil through roots and these are translocated to other parts of the plant body dissolved in water. However, besides absorbing minerals from natural sources, crops receive nutrients mainly by fertilization, manuring and irrigation of crop fields. Weeds growing in association with the crop share a large amount of minerals from soil, and thus depleting the nutrients from soil. This ultimately affects the growth and mineral status of crop.

Although nitrogenous compounds constitute only a small proportion of the total dry weight of plants, still it is an important element because of its physiological activity. Plants require nitrogen from the beginning of the growth period till maturity and deficiency of nitrogen is responsible for disappearance of green colour due to failure to synthesize normal amounts of chlorophyll. Nitrogen is also essential for the production of proteins. Nitrogen concentration in various tissues of plants varies with age and stage of growth. Highest concentration of nitrogen is found in the meristmatic tissues i.e., leaves, root tips and stem tips. Seeds also are often high in

nitrogen, but this is chiefly in the form of reserve food (Kramer and Kozlowaski, 1960).

Like nitrogen, phosphorus is another essential element for normal growth of plants. In the plant body, phosphorus is utilised in the formation of nucleoproteins, phospholipids and high energy compounds like ATP, associated with phosphate groups which are chief medium for energy transfer in plants. Deficiency of phosphorus results in several morphological and physiological abnormalities in plants (Stumpf, 1952 and Aslander, 1958) and thus reduce the productivity (Aslander, 1958 and Russel, 1963).

Although deficiency of minerals can be eliminated to some extent by the use of fertilizers but still availability of these depends on a number of factors. The structure of a plant community has also been found to affect the phosphate uptake by plants (Pandey, 1968). Gregory (cf. Williams, 1955) has emphasized the role of redistribution of nitrogen and phosphorus in governing the final yield of weeds. He also stated that 90 percent of the total nitrogen and phosphorus, contents of cereals are absorbed when the dry weight is only 25 percent of the total value. They are first absorbed by initial leaves and then withdrawn as the leaves become senescent and used in newly formed inflorescence for production of seeds. Therefore, it can be concluded that availability of these elements at vegetative stage affects the crop yield at a later stage.

In order to understand the present investigation the translocation

of nitrogen and phosphorus through crop plants at different stages of growth as affected by weed infestation, profile distribution of these elements in different components of wheat has been studied during different stages of crop.

METHODS

PROFILE DISTRIBUTION OF NITROGEN AND PHOSPHORUS IN WHEAT CROP

All the component parts of wheat (leaf, stem, ear and root) and weeds (leaf, stem and root) were separated in vertical profiles of 20 cm. Chemical analysis of plant materials for nitrogen and phosphorus was done by methods described by Jackson (1958), and percentage of nitrogen and phosphorus content mg/g was calculated. This was done at three stages of growth vegetative, flowering and fruiting.

UPTAKE, RELEASE AND RETENTION OF NITROGEN AND PHOSPHORUS

The uptake of phosphorus and nitrogen was calculated by multiplying the nitrogen and phosphorus contents (mg/g) with net dry matter production. Similarily release was calculated by multiplying the phosphorus and nitrogen contents (mg/g) of litter with litter production. In the case of wheat litter included dead leaves and roots because roots are left in the soil

after harvesting. The difference between the uptake and release gives the value of retention of these nutrients.

RESULTS

DISTRIBUTION OF NITROGEN IN WHEAT

Nitrogen in various components of wheat with the height of the plants as well as stage of growth. At vegetative stage distribution of nitrogen in plant body is almost uniform in both pure and mixed stands of wheat with only insignificant variations. However, at later stages of growth nitrogen content of wheat plant in mixed stand was significantly reduced as compared to values found in pure stand of wheat (Table 5.1). Non-green parts had a comparatively lower nitrogen percentage ranging from 0.75 to 2.75 percent.

Further it was observed that concentration of nitrogen increased towards growing regions that is towards upper layers of the canopy in all components (Leaf, stem and ear).

The total nitrogen content g/m^2 of wheat in PS and MS was found to vary with age of the crop. At vegetative stage nitrogen content of wheat (g/m^2) was 1.5249 and 1.007 in PS and MS respectively which increased to 30.9754 and 52.8002 in PS and 17.9053 and 26.0142 in MS at flowering and fruiting stages respectively (Table 5.2; Fig. 5.1).

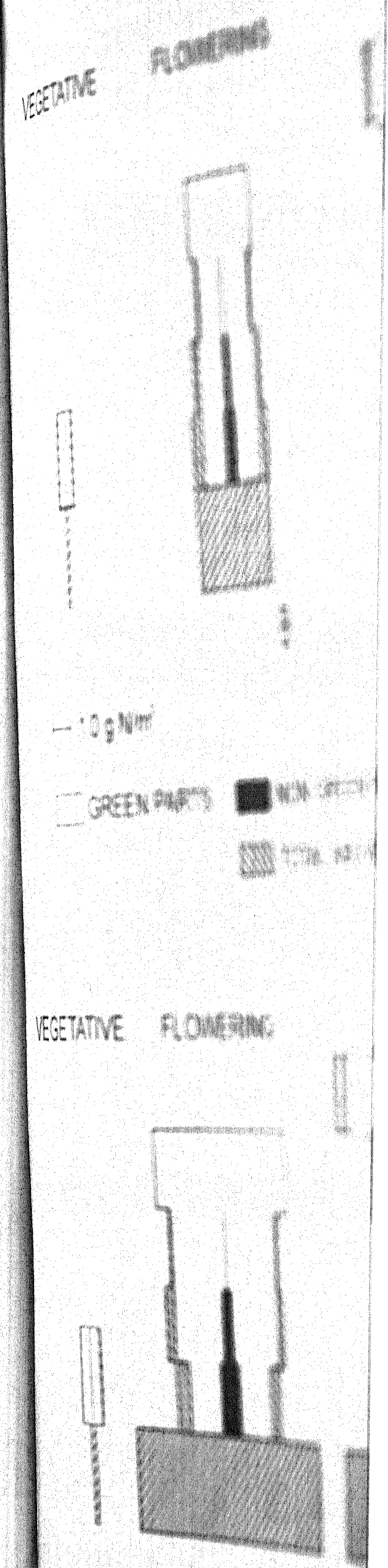
Table 5.1 : Stratal variations in the percentage nitrogen content of various components of wheat in a pure and mixed stands of wheat

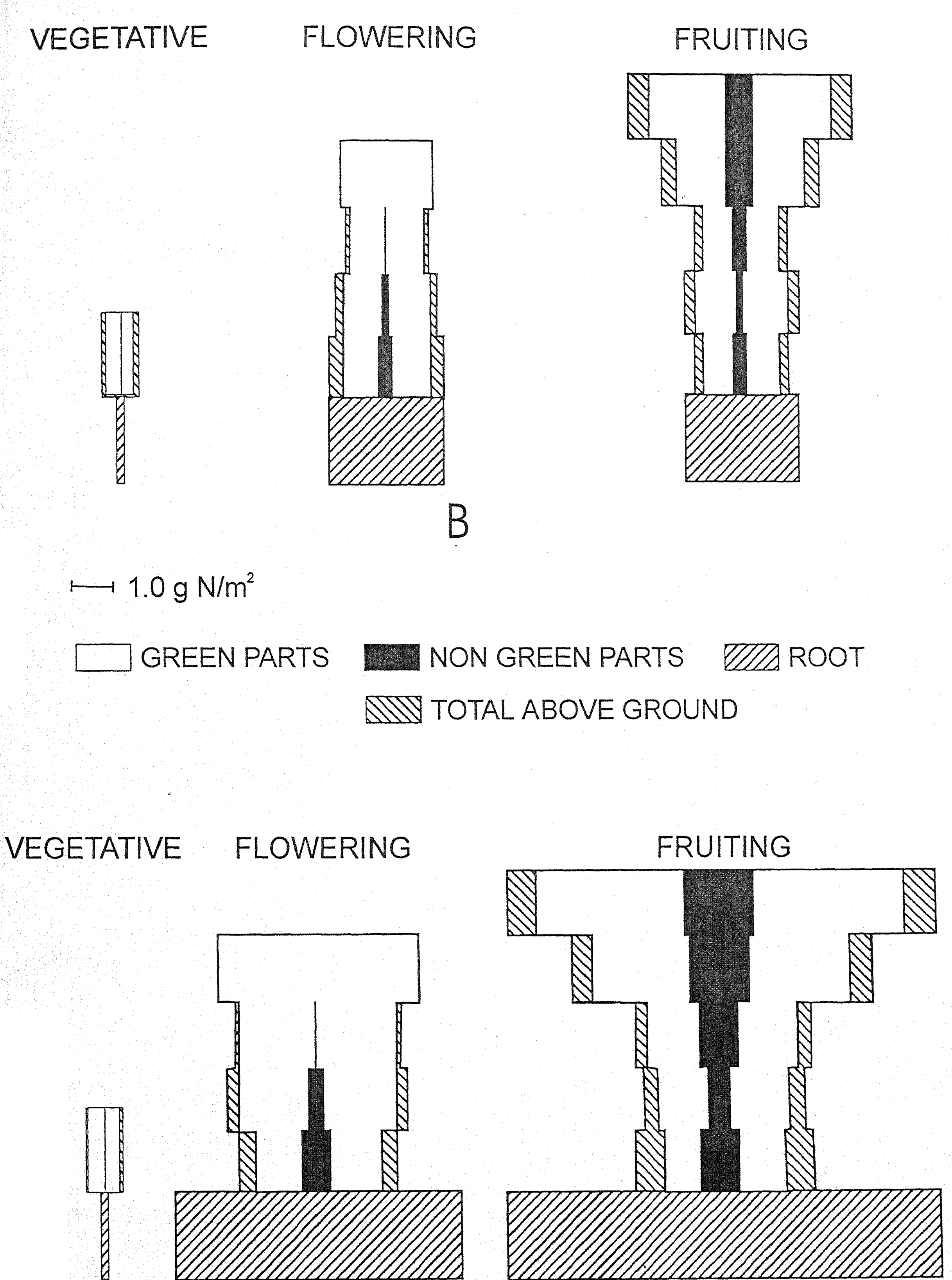
Stage	Height (cm)	Stand	Photosynthetic parts			Non-photosynthetic parts			
			Leaf	Stem	Ear	Leaf	Stem	Ear	Root (0-25 cm)
Vegetative	0-20	PS	1.48	1.58	–	–	1.25	–	1.48
		MS	1.45	1.50	–	–	1.00	–	1.45
		't' Value	**0.58**	**0.92**	–	–	**0.71**	–	**0.76**
Flowering	0-20	PS	1.75	1.25	–	1.23	1.00	–	2.66
		MS	0.75	1.25	–	1.00	0.95	–	2.25
		't' Value	**4.98***	**0.26**	–	**2.19**	**0.24**	–	**5.12***
	20-40	PS	1.41	2.25	–	1.23	1.00	–	–
		MS	1.35	1.50	–	1.03	0.75	–	–
		't' Value	**4.96***	**5.26***	–	**2.42**	**0.75**	–	–
	40-60	PS	1.91	2.50	1.58	1.25	1.00	–	–
		MS	1.38	1.50	1.25	1.00	0.75	–	–
		't' Value	**5.45***	**4.42***	**2.64**	**0.98**	**1.25**	–	–
	60-80	PS	2.33	2.66	2.66	–	–	–	–
		MS	1.25	1.75	1.50	–	–	–	–
		't' Value	**4.87***	**6.19***	**5.96***	–	–	–	–
Fruiting	0-20	PS	1.23	1.25	–	1.20	1.00	–	2.50
		MS	1.00	1.00	–	1.00	0.75	–	1.25
		't' Value	**1.21**	**5.45***	–	**1.21**	**1.15**	–	**5.45***
	20-40	PS	1.66	1.50	–	1.36	0.98	–	–
		MS	1.25	1.24	–	1.00	0.75	–	–
		't' Value	**1.45**	**6.94***	–	**2.85**	**1.42**	–	–
	40-60	PS	2.00	1.83	1.58	1.36	1.25	1.50	–
		MS	1.50	1.23	1.20	1.20	1.00	1.00	–
		't' Value	**4.98***	**5.15***	**1.38**	**1.46**	**1.16**	**1.42**	–
	60-80	PS	2.25	2.08	2.66	1.38	1.25	2.00	–
		MS	1.75	1.75	1.45	1.25	1.00	1.75	–
		't' Value	**5.22***	**5.21***	**7.82***	**0.46**	**1.21**	**4.32***	–
	80-100	PS	2.25	2.00	2.91	1.75	1.59	2.75	–
		MS	1.50	1.75	2.00	1.25	1.00	1.91	–
		't' Value	**4.96***	**1.48**	**4.98***	**2.26**	**1.82**	**5.96***	–

Table 5.2 : Stratal variations in nitrogen content (g/m^2) in different components of wheat in pure and mixed stands of wheat

Stage	Height	Stand	Photosynthetic parts				Non-photosynthetic parts				Total above	Root	Total
	(cm)		Leaf	Stem	Ear	Total	Leaf	Stem	Ear	Total	Ground	(0-25 C)	
Vegetative	0-20	PS	0.5848	0.3817	–	0.9665	–	0.1093	–	0.1093	1.0758	0.4491	1.5249
		MS	0.4222	0.2742	–	0.6964	–	0.0529	–	0.0529	0.7493	0.3514	1.1007
Flowering	0-20	PS	0.8456	2.9260	–	3.7716	0.2859	0.7985	–	1.0844	4.8560	8.8434	30.9754
		MS	0.2862	2.2880	–	2.5742	0.1181	0.5719	–	0.6890	3.2632	6.8067	17.9053
	20-40	PS	0.9091	3.7836	–	4.6927	0.2761	0.5621	–	0.8382	5.5309		
		MS	0.5389	2.0496	–	2.5885	0.1917	0.2679	–	0.4596	3.0481		
	40-60	PS	1.2804	2.9600	0.4247	4.6651	0.0920	0.0465	–	0.1385	4.8036		
		MS	0.5508	1.4064	0.2020	2.1592	0.0225	0.0174	–	0.0399	2.1991		
	60-80	PS	1.0811	0.7575	5.1029	6.9415	–	–	–	–	6.9415		
		MS	0.3970	0.2688	1.0224	2.5882	–	–	–	–	2.5882		
Fruiting	0-20	PS	0.4211	2.9520	–	3.3731	0.3774	0.8261	–	1.2035	4.5766	14.2605	52.8002
		MS	0.2721	1.6432	–	1.9153	0.2236	0.4818	–	0.7054	2.6207	5.7040	26.0142
	20-40	PS	0.4488	2.9424	–	3.3912	0.3466	0.5718	–	0.9184	4.3096		
		MS	0.3580	1.9264	–	2.2844	0.2241	0.2451	–	0.4692	2.7536		
	40-60	PS	0.8160	2.6410	0.0556	3.5126	0.3574	0.4031	0.2137	0.9742	4.4868		
		MS	0.5376	1.4268	0.0278	1.9222	0.2562	0.2638	0.0843	0.6043	2.5965		
	60-80	PS	0.4140	1.0682	8.3460	9.8282	0.1967	0.1553	1.0852	1.4372	11.2654		
		MS	0.1400	0.7532	3.3268	4.2200	0.1181	0.0689	0.5685	0.7555	4.9755		
	80-100	PS	0.0396	0.1312	11.9100	12.0808	0.0404	0.0639	1.7162	1.8205	13.9013		
		MS	0.0120	0.0784	6.4894	6.5798	0.0170	0.0135	0.7536	0.7841	7.3639		

Fig.5.1: Vertical distridution of nitrogen content of wheat (g/m^2) in A. pure stand and B.mixed stand.




VEGETATIVE
FLOWERING
FRUITING
B
1.0 g N/m²
GREEN PARTS
NON GREEN PARTS
ROOT
TOTAL ABOVE GROUND
VEGETATIVE
FLOWERING
FRUITING

NITROGEN CONTENT OF WEEDS

Nitrogen content (%) of weeds in mixed stand of wheat was also found to be considerably high with highest concentration in stem and roots. Leaves had comparatively low nitrogen content (Table 5.3).

Nitrogen content mg/m^2 was found to increase with age and maximum value of 5.384 g/m^2 was found at fruiting stage of crop. However, it was found that underground parts of weeds had higher nitrogen contents (g/m^2) (Table 5.4) because of more biomass accumulation in underground parts.

Table 5.3 : Percentage nitrogen content and phosphorus content (mg/g) in different components of weeds at different stages of growth in mixed stand of wheat

Stage	Height	Nitrogen content (%)			Phosphorus content (mg/g)		
		Leaf	Stem	Root	Leaf	Stem	Root
Vegetative	0-20	1.56	1.58	1.48	4.34	4.56	2.56
Flowering	0-20	2.50	2.75	2.66	5.32	5.94	4.38
Fruiting	0-20	2.25	2.50	2.50	3.24	3.72	3.10

Table 5.4 : Nitrogen and phosphorus content (mg/m^2) of weeds in mixed stand of wheat

Nitrogen content (mg/m^2)					Phosphorus content (mg/m^2)				
Leaf	Stem	Total ab.gr.	Root	Total	Leaf	Stem	Total ab.gr.	Root	Total
79.87	247.11	326.98	5390.3	5717.3	22.22	71.31	93.53	1193.12	1286.65
312.00	360.80	672.80	4651.80	5324.6	72.63	77.73	150.36	765.97	916.33
770.40	906.25	1676.65	5384.0	7060.6	110.93	134.85	245.78	886.13	1131.91

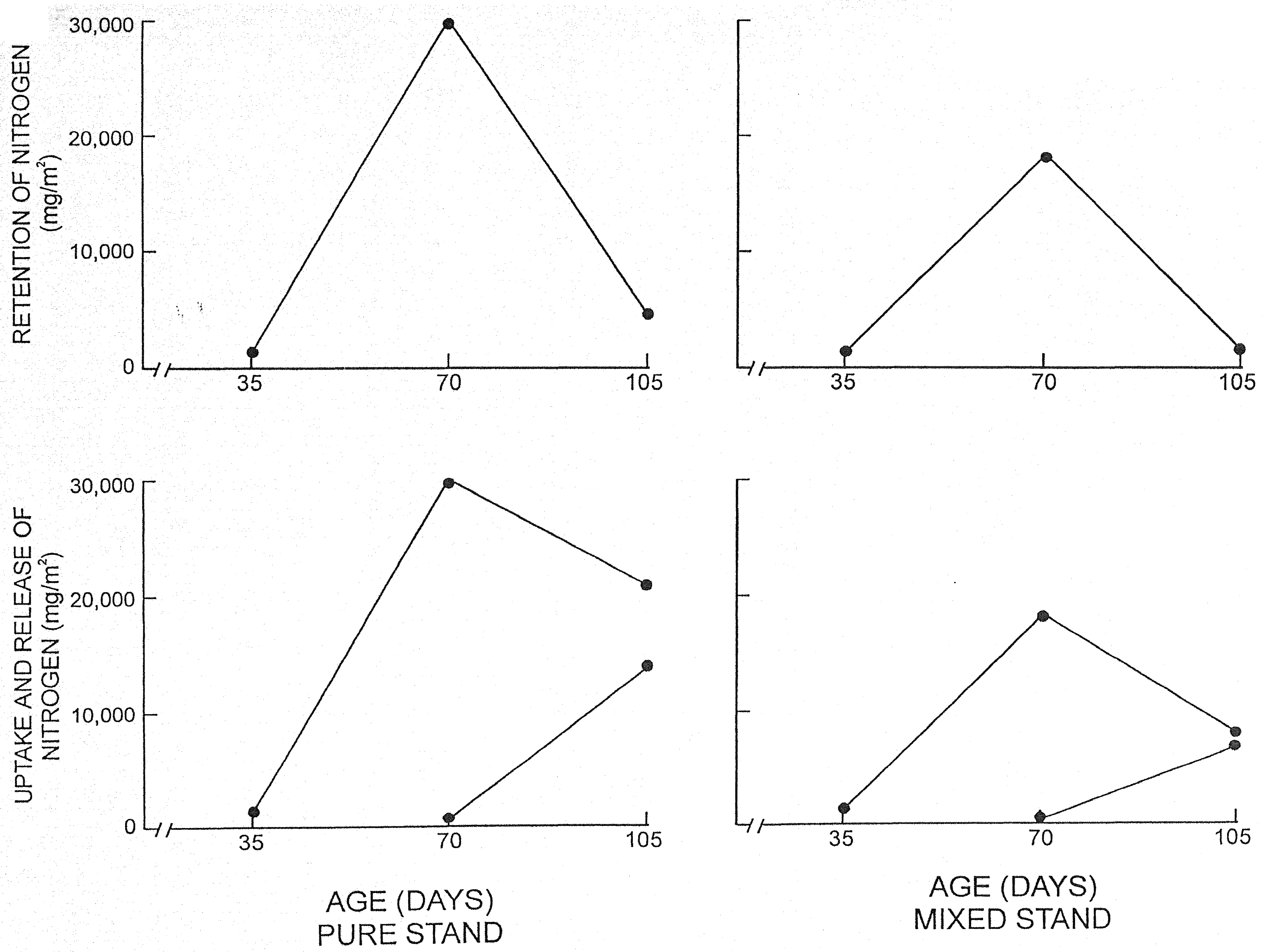
Veg. = Vegetative, Flo. = Flowering, Fru. = Fruiting, Gr. = Aboveground

UPTAKE, RELEASE AND RETENTION OF NITROGEN BY WHEAT

Rate of uptake of nitrogen by wheat was influenced with age of the crop. At vegetative stage uptake was 1524.99 and 1100.70 mg/m^2 in pure and mixed stands respectively. Maximum uptake of nitrogen by wheat occurred at flowering stage of the crop i.e., 29450.5 and 17804.6 mg/m^2 in PS and MS respectively. Again at fruiting stage it declined (Table 5.5; Fig. 5.2). There was no litter fall at vegetative stage so the whole amount taken up by the plants was retained, however at flowering stage amount of leaf was recorded 3.61 and 3.30 g/m^2 in PS and MS respectively. Further at fruiting stage amount of litter (including roots) was found to be 7.05 and 6.70 g/m^2 in the two stands.

Thus the amount of nitrogen released was 654.0 and 352.3 mg/m^2 in PS an MS and 15579.0 and 6543.0 mg/m^2 in PS and MS at flowering and fruiting stages respectively. The total amount which is retained during

Fig.5.2: Variation in the uptake, release and retention of nitrogen (mg/m^2) by wheat in pure and mixed stands of wheat at three stages of growth.


RETENTION OF NITROGEN (mg/m^2)
UPTAKE AND RELEASE OF NITROGEN (mg/m^2)
30,000
20,000
10,000
0
35
70
105
AGE (DAYS)
PURE STAND
AGE (DAYS)
MIXED STAND

growth period was 36567.2 and 20138.9 mg/m^2 in PS and MS respectively (Table 5.5; Fig. 5.1).

Table 5.5 : Uptake, release and retention of phosphorus and nitrogen in wheat at different stages of growth in pure and mixed stands

Stage	Stand	Phosphorus (mg/m^2)			Nitrogen (mg/m^2)		
		Uptake	Release	Retention	Uptake	Release	Retention
Vegetative	PS	456.27	-	456.27	1524.90	-	1524.90
	MS	313.04	-	313.04	1100.70	-	1100.70
Flowering	PS	7337.84	202.49	7135.35	29450.50	654.0	28796.50
	MS	4621.07	102.57	4519.50	17804.60	332.3	17472.13
Fruiting	PS	3831.35	3479.62	351.73	21824.80	15579.0	6245.80
	MS	2550.22	2407.66	143.56	8108.90	6543.0	1565.90
Total	PS	11625.46	3682.11	7943.58	52800.20	16233.0	36567.20
	MS	7484.33	2510.23	4976.10	27014.20	6875.3	20138.90

DISTRIBUTION OF TOTAL PHOSPHORUS IN WHEAT

Phosphorus varied significantly in different components of wheat in pure and mixed stands with age similar to that of nitrogen. At vegetative stage however, there was insignificant difference in the phosphorus content mg/g of all components in PS and MS. But at later stages of growth there was significant reduction in the phosphorus content of wheat plants in MS as compared to that of pure stand (Table 5.6).

The total phosphorus content of wheat was 456.27 and 313.04 mg/m^2 in PS and MS respectively at vegetative stage. However, it increased with age and was maximum at fruiting stage i.e., 11625.46 and 7484.33

mg/m^2 in PS and MS respectively (Table 5.7). The phosphorus content was more in growing regions of wheat.

Phosphorus content (mg/g) of weeds was highest at flowering stage of crop in all components (5.82 mg/g in leaves; 5.94 mg/g in stem and 4.38 mg/g in root).

Phosphorus content was maximum at vegetative stage of crop growth 1286.65 mg/m^2 then it decreased to 916.33 mg/m^2 at flowering. At fruiting stage, again it increased to a value of 1131.91 mg/m^2 (Table 5.7; Fig. 5.3).

UPTAKE, RELEASE AND RETENTION OF PHOSPHORUS IN WHEAT

Uptake of phosphorus was found to be maximum at flowering stage i.e., 7337.84 and 4621.07 mg/m^2 in PS and MS respectively, and 3831.35 and 2550.22 mg/m^2 at fruiting stage in PS and MS respectively.

Phosphorus release through litter fall was maximum at fruiting stage of the crop i.e., 3479.62 and 2407.66 mg/m^2 in PS and MS respectively. Thus, it was found that the amount of phosphorus retained by wheat plants was reduced by more than 50 percent in MS as compared to pure stand (351.73 and 143.56 mg/m^2 in PS and MS respectively) (Table 5.5; Fig. 5.4).

Fig.5.3: Vertical distribution of phosphorus content mg/m^2 of wheat in A. pure stand and B. mixed stand.

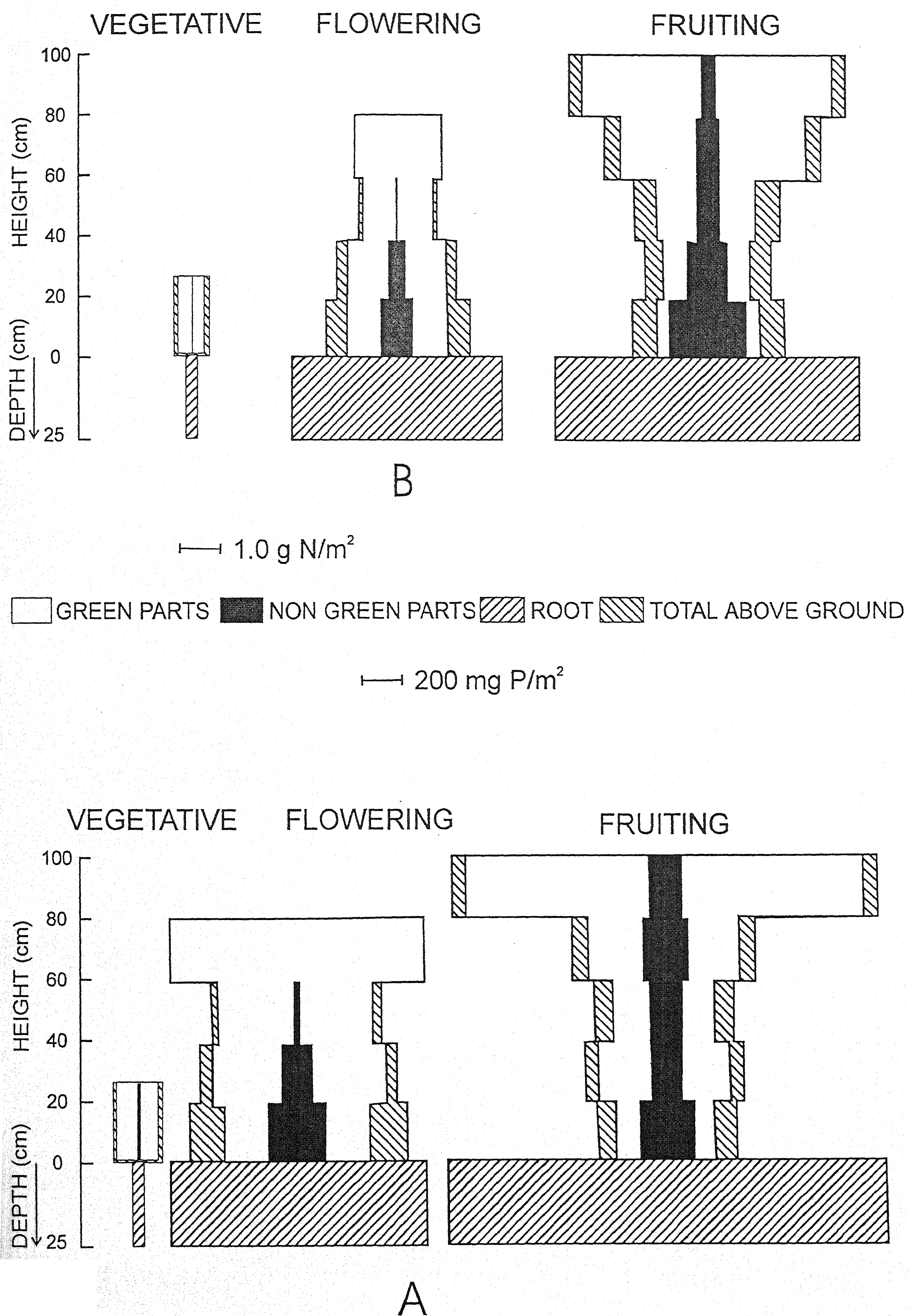

VEGETATIVE
FLOWERING
FRUITING
HEIGHT (cm)
DEPTH (cm)
100
80
60
40
20
0
25
B
1.0 g N/m²
GREEN PARTS
NON GREEN PARTS
ROOT
TOTAL ABOVE GROUND
200 mg P/m²
VEGETATIVE
FLOWERING
FRUITING
HEIGHT (cm)
DEPTH (cm)
100
80
60
40
20
0
25
A

Table 5.6 : Vertical distribution of phosphorus content (mg/g) of wheat in pure and mixed stands of wheat

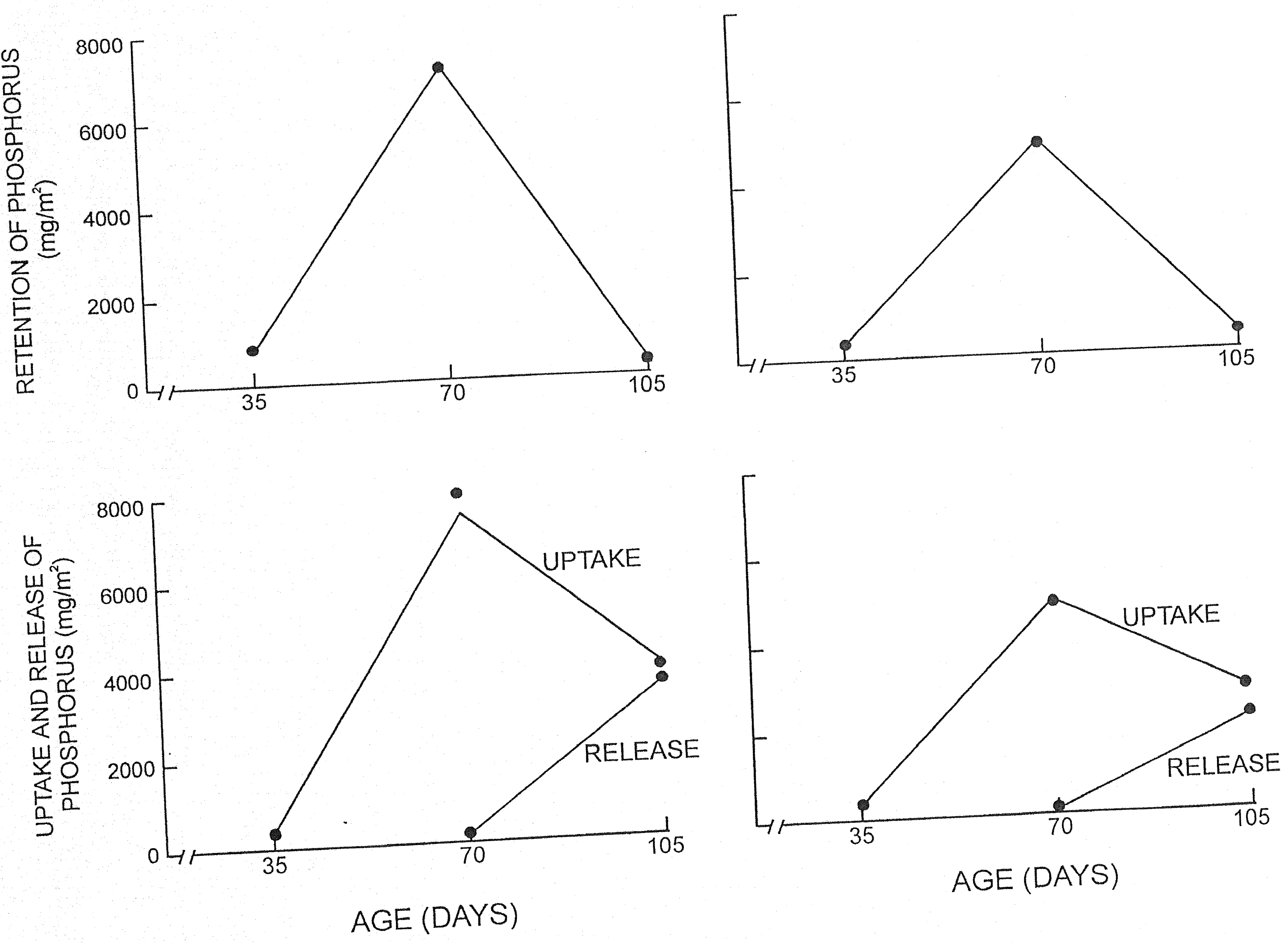
Stage	Height (cm)	Stand	Photosynthesis parts			Non-photosynthetic parts			
			Leaf	Stem	Ear	Leaf	Stem	Ear	Root (0-30 cm)
Vegetative	0-20	PS	4.30	4.40	–	–	4.32	–	4.70
		MS	3.96	3.96	–	–	3.72	–	4.36
		't' Value	**2.11**	**1.32**	–	–	**1.24**	–	**0.98**
Flowering	0-20	PS	3.75	4.02	–	3.75	3.78	–	5.96
		MS	3.36	3.75	–	3.00	3.39	–	4.80
		't' Value	**1.42**	**2.28**	–	**0.82**	**1.36**	–	**4.45***
	20-40	PS	4.74	5.04	–	3.75	3.34	–	–
		MS	4.77	4.56	–	3.18	3.42	–	–
		't' Value	**4.92***	**2.45**	–	**2.89**	**1.14**	–	–
	40-60	PS	4.98	5.55	4.38	4.23	4.08	–	–
		MS	4.26	4.68	3.75	3.66	4.08	–	–
		't' Value	**5.27***	**4.96***	**4.95***	**2.94**	–	–	–
	60-80	PS	7.17	7.44	5.76	–	–	–	–
		MS	4.74	5.82	4.14	–	–	–	–
		't' Value	**8.96***	**3.45***	**5.14***	–	–	–	–
Fruiting	0-20	PS	2.92	3.50	–	2.70	2.72	–	5.36
		MS	2.64	2.64	–	2.24	3.32	–	4.64
		't' Value	**5.21***	**5.41***	–	**1.25**	**1.32**	–	**5.91***
	20-40	PS	3.04	3.72	–	2.92	2.72	–	–
		MS	2.64	2.64	–	2.30	2.44	–	–
		't' Value	**9.42***	**6.25***	–	**5.14***	**1.46**	–	–
	40-60	PS	3.66	3.96	3.92	3.70	3.08	2.64	–
		MS	3.28	3.22	3.24	2.68	2.62	2.42	–
		't' Value	**4.26***	**2.98***	**2.82**	**5.26***	**4.99***	**1.21**	–
	60-80	PS	4.52	5.12	5.74	3.96	3.92	3.58	–
		MS	4.06	3.84	4.40	2.90	2.84	3.06	–
		't' Value	**5.11***	**5.25***	**4.24***	**5.15***	**5.21***	**1.48**	–
	80-100	PS	5.96	5.96	6.96	3.96	4.42	3.92	–
		MS	4.28	4.66	5.28	3.10	3.70	3.16	–
		't' Value	**4.48***	**5.22***	**5.31***	**2.75**	**2.14**	**2.23**	–

Significant at 5% level.

Table 5.7 : Vertical distribution of phophorus content (mg/m^2) of wheat in pure and mixed stand of wheat

Stage	Height (cm)	Stand	Photosynthetic Parts				Non-photosynthetic parts				Total above Ground	Root	Total
			Leaf	Stem	Ear	Total	Leaf	Stem	Ear	Total			
Vegetative	0-20	PS	169.53	106.30	–	275.83	–	37.80	–	37.80	313.63	142.64	456.27
		MS	115.31	72.38	–	187.69	–	19.67	–	19.67	207.36	105.63	313.04
Flowering	0-20	PS	181.20	941.00	–	1122.20	87.18	301.83	–	389.01	1511.21	1981.46	7794.11
		MS	128.21	606.40	–	814.61	85.13	204.11	–	239.24	1053.35	1452.09	4934.11
	20-40	PS	305.60	847.52	–	1153.12	84.13	215.84	–	300.02	1453.12		
		MS	178.44	623.07	–	801.51	89.21	122.16	–	181.37	982.85		
	40-60	PS	333.85	657.12	117.73	1108.70	31.13	19.01	–	50.14	1158.84		
		MS	157.70	438.79	60.60	657.09	8.23	9.46	–	17.69	674.78		
	60-80	PS	332.68	211.89	1104.99	1649.56	–	–	–	–	1649.56		
		MS	150.54	89.39	530.58	770.51	–	–	–	–	770.51		
Fruiting	0-20	PS	99.98	526.50	–	626.48	84.91	224.69	–	309.60	936.08	3057.45	11625.46
		MS	71.83	433.80	–	505.63	50.08	213.31	–	263.39	769.02	2117.32	7484.33
	20-40	PS	82.20	729.71	–	811.91	74.43	158.71	–	233.14	1045.05		
		MS	75.60	410.15	–	485.75	51.54	79.76	–	131.30	617.05		
	40-60	PS	149.32	571.50	13.76	734.58	97.23	99.33	37.62	234.18	968.76		
		MS	117.55	373.52	7.51	498.58	57.11	69.11	20.40	146.62	645.20		
	60-80	PS	83.16	262.96	1800.98	2147.10	56.46	48.72	194.25	299.43	2446.53		
		MS	32.48	165.27	1009.53	1207.28	27.40	19.56	99.41	146.37	1353.65		
	80-100	PS	11.62	39.09	2848.58	2899.29	9.14	18.82	244.64	272.60	3171.89		
		MS	7.53	20.87	1818.80	1847.20	4.21	4.99	124.69	133.89	1981.09		

Fig.5.4: Variation in the uptake, release and retention of phosphorous (mg/m^2) by wheat in pure and mixed stand of wheat at three stages of growth.


RETENTION OF PHOSPHORUS (mg/m²)
8000
6000
4000
2000
0
35
70
105
UPTAKE AND RELEASE OF PHOSPHORUS (mg/m²)
UPTAKE
RELEASE
AGE (DAYS)

DISCUSSION

It is clear from the present study that rate of uptake of nitrogen and phosphorus in wheat vary significantly in pure and mixed stands at different stages of growth. Weeds through their fast growing habit keep an upper hand over the crop at early stages of growth and hence the total uptake by all weeds exceeds the demand of a single crop, although individually they seem to be less harmful (Pandey, 1968). Present data too, indicates that in pot culture experiments (described in Chapter VI) where only **V. hirsuta** was competing with wheat the uptake of nitrogen and phosphorus by wheat was comparatively less affected as compared to the field conditons where many other weeds competed with the crop. The maximum concentration of nitrogen and phosphorus was found in the ears of wheat at fruiting stage in both pure and mixed stand, it is evident from the data (Tables 5.1 and 5.6) that the percentage of these elements in wheat plants was considerably lower in the mixed stand as compared to pure stand.

Mineral's translocation in plants, involves the upward movement of the inorganic materials acquired by the roots, their distribution within the shoot and redistribution via the vascular tissue from the initial site of deposition to any other part of the plant (Biddulph, 1959). The redistribution of minerals may occur in two ways (1) the withdrawal of elements from leaves prior to their absicission and (2) the transfer of elements initially

deposited in leaves, stems etc., to reproductive or other structures.

In the present study data obtained shows that at vegetative stage nitrogen and phosphorus are almost uniformly distributed in all plant parts of wheat, leaf, stem and root but as the plants grow further at flowering and fruiting stages it was observed that nitrogen (%) and phosphorus (mg/g) increased upward with maximum concentration in the inflorescence and apical meristems of leaf and stem in both pure and mixed stands (Tables 5.1 and 5.6).

On the basis of he experiments stumpf (1952) concluded that highest accumulation of phosphate was found in meristematic regions within the body of plant and as the meristematic regions shift with age, accumulation of phosphate also keeps shifting with it. Gregory (1926) drew attention to the fact that over 90 percent of the nitrogen and phosphorus is taken up and accumulated by the developing cereal plant when the dry weight was only 25 percent of the final value. This store of accumulated nutirent was the reserve on which depended the later growth and development and the final yield. In the present study it was found that the reduction in the concentration of nitrogen and phosphorus in wheat which started at the vegetative stage itself due to the interference of weeds in mixed stand affected the uptake of these elements in the later stages of growth and ultimately resulted in lower yield by reducing the production of wheat both qualitatively and quantitatively.

Nitrogen and phosphorus concentration was higher in leaves of wheat when they were young. It is generally assumed that minerals are carried alongwith the upward flow of water. Stout and Hogland (1939) stated that the path of upward translocation of minerals is through the xylem in plants under normal growth conditions where leafy shoots are present.

Since the minerals are released into the xylem, they come under the influence of the ascending transpiration stream which has the effect of sweeping them in the direction of its flow (Biddulph, 1959). Maximov (1929) showed that the youngest leaves have the highest transpiration rate and consequently are aided in accumulating within themselves a sufficient quantity of minerals for their growth.

A positive correlation has been obtained in the percentage of water, nitrogen and phosphorus contents of various plant parts of wheat at all stages of growth. This further supports the general conclusion that minerals and water ascend together in the plant body and the same channel is used for ascension of both water and solutes.

In general sense there are two basic phenomenon which influence the direction of movements of minerals within a plant metabolic use and transpiration. The intensity of these two factors determines the net movement of minerals in that tissue. In young leaves active metabolism favours the continuous movement of minerals in these and the minerals thus acquired

are utilized in the formation of protoplasm. On the other hand in older leaves metabolic activity is comparatively very low while transpiration is high.

In the present investigation results show that nitrogen and phosphorus are withdrawn from older tissues (leaves and stem) and move to the meristematic areas where they get accumulated in higher concentrations. Gregory (1926) has shown that nitrogen and phosphorus set free from the senescent leaves and tillers were reutilized for production of further leaves which in turn provided for the development of inflorescence. Miller (1967) also cited examples of their migration from stem to ear in graminaceous plants. Knowles and Watkins (1931) on the basis of their data for wheat showed marked transport of nitrogen and phosphorus from stem to ear.

On the basis of the present data it can be concluded that mineral concentration and distribution in plant parts of wheat (nitrogen and phosphorus) effect the water content, photosynthetic area, chlorophyll as well as the dry matter production of wheat in pure and mixed stands. While uptake of these elements by wheat plants is affected significantly by the interference of weeds in the mixed stand.

CHAPTER VI

INTRA AND INTERSPECIFIC COMPETITION

INTRA AND INTERSPECIFIC COMPETITION

INTRODUCTION

In plant ecology the study of plant competition is of basic importance. Competition between plants occurs when the supply of any one or more of the essential factors i.e., light, water, nutrients, space or any other environmental factor becomes limiting to the crop. When groups of seedlings especially of the same species, are closely grouped, competition begins almost immediately and growth is affected (Clements, 1938). Harper (1961) used the term "Interference" to define all those hardships which are caused by the proximity of neighbours. To most ecologists the term 'competition' implies all those forces by which one organism succeeds at the expense of another. The problem of crop-weed interaction has been known to agronomists for a long time as it reduces the grain yield of the desired crops. However, ecologists look to the problem, from a somewhat broader angle in which besides grain yield total primary production of the cropland ecosystem is considered.

Cropland ecosystem is an artificial and man made ecosystem in which crop plants are the chief primary producers. However, besides the purposely sown crop species some other undesirable weeds also come up invariably and grow along with the crop sharing nutrients, light, water and other growth factors with it and thus competing with the crop plants. In a

cropland ecosystem competition may occur in two ways (1) Intraspecific competition-occurs between the plants of the same species i.e., mainly between the individuals of crop species itself and, (2) interspecific competition occurs between plants of two or more different species. Under this type of competition interaction between crop species and weeds have been considered here.

Plant's growth could be influenced by other plants of the same population in different ways. Density of plants in the population could affect their growth due to the limited space and nutrition available to individual plants. Interspecific competition may arise due to a number of different factors - (1) the density of plants in a unit area affects the plant growth to a considerable extent due to less availability of space and other growth factors per plant. Species with higher competitive ability succeed the others, (2) besides density, distribution of plants in space is another important factor leading to competition among plants. Harper (1961) states that yield of the crop may be influenced greatly by the spatial pattern of distribution of its immediate neighbours.

Competition among plants may vary from species to species due to variation in their competitive abilities. The severity of competition may also vary at different stages of development.

In the present study inter and intraspecific competition in wheat and Vicia hirsuta (a dominant weed of wheat fields) as influenced by

different levels of density in pure and mixed cultures and variations in the spatial pattern of distribution of the two species have been studied. The intensity of competition has been observed on the basis of dry matter production, leaf area, number of tillers, number of leaves and height of plants, nitrogen and phosphorus content at various growth stages of wheat.

METHODS

INTRASPECIFIC COMPETITION

Plants of wheat and Vicia hirsuta were transplanted in separate pots of 1000 sq. cm. area at 3 densities of wheat (1,5,9 plants per pot) and four densities of Vicia hirsuta (1,10,15 and 20 plants per pot). Dry matter production of all plant parts, leaf area, number of tillers and leaves per plant (of wheat), height of plants, nitrogen and phosphorus contents were estimated at vegetative, flowering and fruiting stages of wheat.

INTERSPECIFIC COMPETITION

(A) EFFECT OF DISTRIBUTION PATTERN

To observe the effect of distribution patterns of wheat and Vicia hirsuta on the production of wheat, the two species were grown in randomized blocks of one sq meter with 100 plants per block (50 plants of each species).

The patterns of arrangement used by Harper (1961) were used

(Fig. 6.1). At the end of the growing season plants were taken out and dry weights of leaf, stem ear and roots were estimated at different stage of plant growth.

(B) EFFECT OF DENSITY

(i) To observe the effect of increasing density of Vicia hirsuta on the production of wheat individuals, plants of two species were grown in earthen pots of surface area approximately 1000 sq. cm. in following combinations.

1 wheat plant per pot

1 wheat + 10 Vicia per pot

1 wheat + 15 Vicia per pot

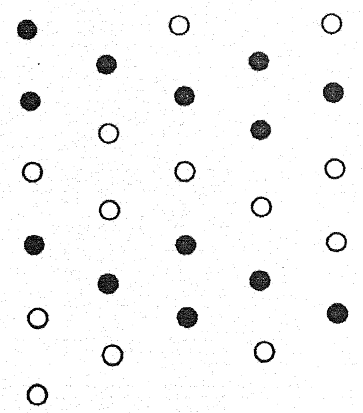
1 wheat + 20 Vicia per pot

At the end of the growing season dry matter production and nitrogen and phosphorus contents of all component parts of wheat (leaf, stem, ear and root) were estimated in all sets.

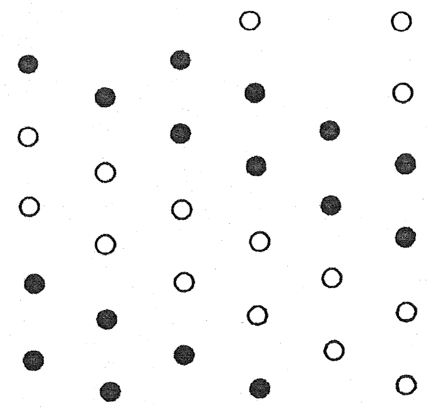
(ii) In mixed cultures maintained at a constant total density of 80 plants/sq. metre but in varied proportions, the two species were grown in equal size pots of 1000 sq. cm. area based on Dewit's model of replacement series (Dewit, 1960) following combinations were setup

Wheat/sq. metre	80	60	40	20	0
Vicia/sq. metre	0	20	40	60	80

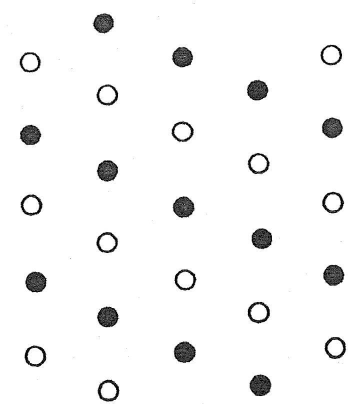
Fig.6.1: Patterns of arrangement used in experiments on competition between wheat and *V. hirsuta*.



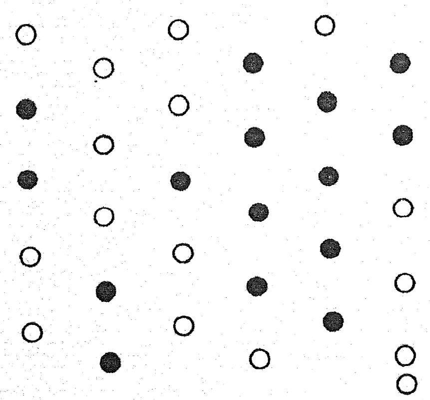
Hexagon 3:3



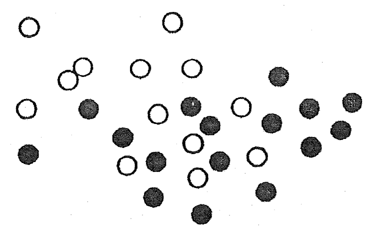
Hexagon 4:2



Hexagon 2:4



Hexagon : Random



Random : Random

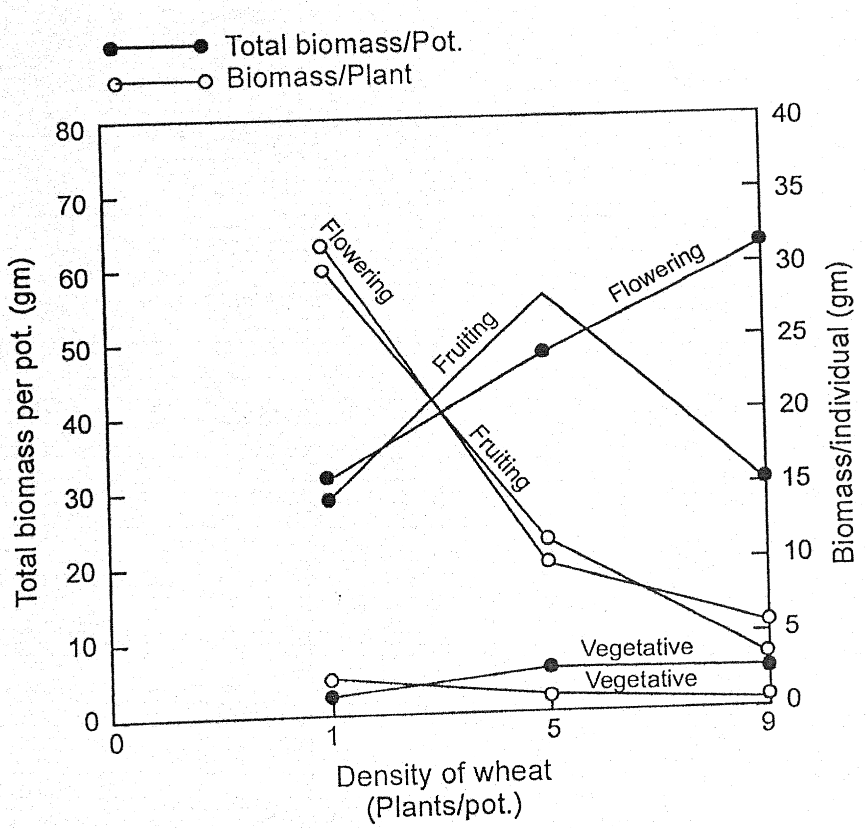
The dry matter production of wheat was estimated at three stages of growth.

RESULTS

INTRASPECIFIC COMPETITIONS IN WHEAT AND VICIA HIRSUTA

Data obtained (Tables 6.1 to 6.6) shows that as the density of plants increases there is a significant decrease in the (i) dry weight per plant, (ii) number of leaves per plant, (iii) number of tillers per plant (in case of wheat), (iv) height of plants, (v) total nitrogen and (vi) phosphorus content of plants. However, as regards the total dry weight per unit area, it increased with increasing density in a linear fashion upto flowering stage of crop in both wheat and Vicia hirsuta but then at fruiting stage it declines significantly when the density increased from 5 and 15 individuals/1000 sq. cm. of wheat and Vicia hirsuta respectively (Fig. 6.2). As the density of plants increased there was a significant decrease in the percentage nitrogen and phosphorus contents (mg/g) in both wheat and Vicia hirsuta from the very beginning of growth till maturity (Fig. 6.3 and 6.4).

Fig.6.2: Effect of increasing density on the dry matter production of plants in pure cultures.


Total biomass/Pot.
Biomass/Plant
Total biomass per pot. (gm)
Biomass/individual (gm)
Flowering
Fruiting
Flowering
Fruiting
Vegetative
Vegetative
Density of wheat
(Plants/pot.)

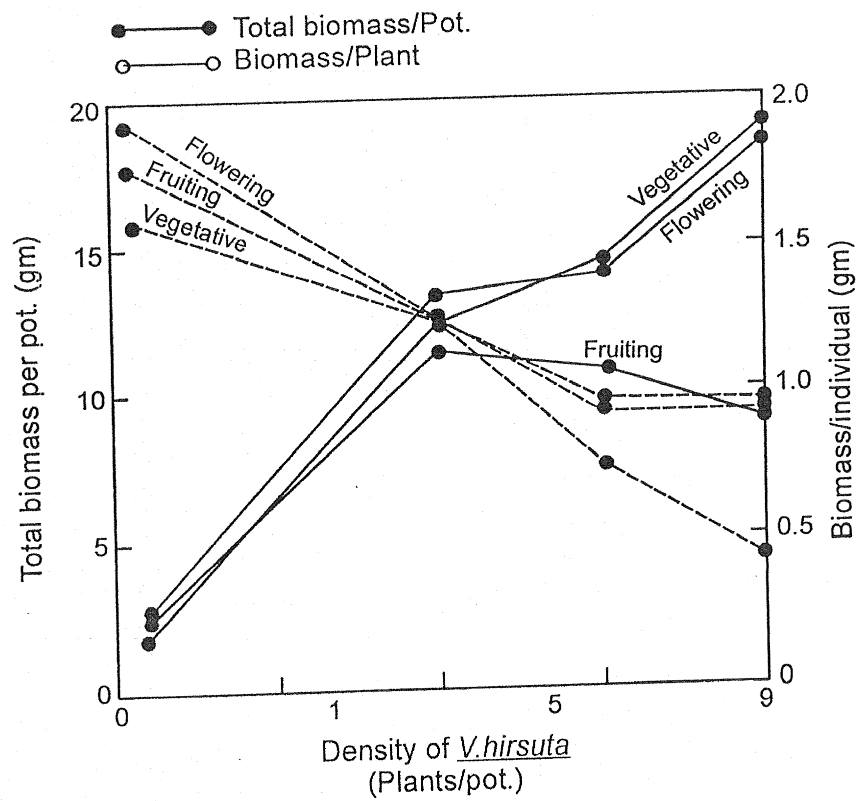

Total biomass/Pot.
Biomass/Plant
Total biomass per pot. (gm)
Biomass/individual (gm)
Flowering
Fruiting
Vegetative
Vegetative
Flowering
Fruiting
Density of V.hirsuta
(Plants/pot.)

Table 6.1 : Dry matter production in mono cultures of wheat at varying densities

Stage	Density (No. of plants/pot)	Total dry wt./pot (g)					Dry wt./plant (g)				
		Root	Stem	Leaf	Ear	Total	Root	Stem	Leaf	Ear	Total
Vegetative	1	1.14	0.38	0.70	–	2.22	1.14	0.38	0.70	–	2.22
		±0.04	±0.02	±0.05		±0.12	±0.04	±0.02	±0.05		±0.12
	5	3.24	1.34	2.32	–	6.90	0.64	0.26	0.46	–	1.36
		±0.15	±0.22	±0.24		±0.62	±0.03	±0.04	±0.04		±0.13
	9	3.89	1.01	1.77	–	6.67	0.43	0.11	0.19	–	0.63
		±0.02	±0.19	±0.03		±0.24	±0.01	±0.02	±0.001		±0.03
Flowering	1	14.02	9.80	5.52	2.74	32.08	14.02	9.80	5.52	2.74	32.08
		±6.66	±2.29	±2.16	±1.00	±9.42	±6.66	±2.29	±2.16	±1.00	±9.42
	5	20.21	16.74	9.57	3.95	50.47	4.04	3.34	1.41	0.79	10.08
		±2.54	±2.75	±1.35	±0.03	±6.42	±0.50	±0.55	±0.26	±0.001	±1.31
	9	21.17	17.54	10.81	2.89	62.41	2.35	1.83	1.20	0.32	5.70
		±1.253	±1.70	±0.41	±2.64	±5.44	±0.14	±0.19	±0.02	±0.08	±0.44
Fruiting	1	18.23	3.68	2.79	5.14	29.84	18.23	3.68	2.79	5.14	29.84
		±0.24	±0.02	±0.32	±0.28	±1.25	±0.24	±0.20	±0.32	±0.28	±0.54
	5	22.28	19.54	5.62	11.69	58.13	4.45	3.90	1.12	2.33	11.80
		±8.26	±4.25	±1.70	±1.97	±13.21	±1.32	±0.92	±0.32	±0.39	±2.95
	9	10.32	7.71	4.25	7.89	30.17	1.14	0.85	0.47	0.87	3.33
		±0.42	±2.15	±0,41	±3.95	±6.42	±0.04	±0.23	±0.04	±0.43	±0.75

Table 6.2 : Effect of increasing density of wheat in pure cultures on morphological characters of wheat

Stage	Density	Plant height (cm)	No. of leaves per plant	No. of tillers per plant
	1	30.30±1.83	28.60±5.13	8.80±1.52
Vegetative	5	31.10±2.43	21.00±4.00	5.60±0.29
	9	29.00±1.92	14.00±3.16	3.30±0.22
	1	78.00±4.78	115.60±15.03	22.3±8.50
Flowering	5	71.60±4.25	35.00±3.24	10.3±2.45
	9	71.20±3.82	21.30±4.50	6.3±0.02
	1	82.76±8.12	115.00±18.25	22.33±4.51
Fruiting	5	72.10±0.02	37.30±0.28	15.60±0.12
	9	71.50±0.22	35.32±5.33	14.20±2.00

Table 6.3 : Variations in percentage nitrogen content in pure cultures of wheat at varying densities

Stage	Density Per pot	Nitrogen content (%)			
		Leaf	Stem	Ear	Root
Vegetative	1	1.48	1.56	–	1.48
	5	1.41	1.42	–	1.45
	9	1.35	1.38	–	1.41
Flowering	1	2.75	2.66	1.58	2.50
	5	1.91	1.75	1.25	2.25
	9	1.75	1.32	1.16	1.75
Fruiting	1	1.85	1.50	2.64	2.19
	5	1.62	1.25	1.54	1.75
	9	1.23	0.96	1.36	1.25

Table 6.4 : Variations in phosphorus content (mg/g) in pure cultures of wheat at varying densities

Stage	Density Per pot	Phosphorus content (mg/g)			
		Leaf	Stem	Ear	Root
Vegetative	1	3.45	3.51	–	3.21
	5	2.91	2.75	–	2.76
	9	2.46	2.19	–	2.32
Flowering	1	3.68	3.25	2.75	3.65
	5	3.21	2.89	2.38	2.91
	9	2.66	2.26	2.18	2.26
Fruiting	1	3.21	2.91	2.96	3.25
	5	2.82	2.56	2.32	2.98
	9	2.19	2.13	1.96	2.28

Table 6.5 : Effect of increasing density on the growth performance and dry matter production of Vicia hirsuta individuals

Stage	No. of plants per pot	Height (cm)	No. of leaves per plant	Dry weight in gm.	
				Per plant	Per pot
Vegetative	1	10.5±1.5	39.0±0.28	1.56±0.26	1.56±0.26
	10	9.4±0.8	27.2±0.35	1.25±0.15	12.50±1.60
	15	9.1±1.2	21.4±2.30	0.98±0.13	14.70±2.43
	20	8.3±0.2	18.9±1.50	0.95±0.61	19.00±0.97
Flowering	1	10.8±1.3	42.0±0.38	1.89±0.14	1.89±0.14
	10	9.5±1.1	31.6±1.20	1.36±0.38	13.60±1.50
	15	8.7±0.92	22.4±0.36	0.97±0.27	14.55±2.30
	20	8.5±0.35	19.5±0.98	0.93±0.32	18.60±3.40
Fruiting	1	10.6±0.18	26.4±0.41	1.75±0.97	1.75±0.97
	10	9.3±0.64	21.5±0.37	1.29±0.14	12.90±0.89
	15	8.6±0.93	18.4±0.36	0.74±0.25	11.10±1.80
	20	8.4±0.87	15.3±1.20	0.45±0.63	9.00±2.40

Table 6.6 : Variations in nitrogen (%) and phosphorus content (mg/g) in pure cultures of Vicia hirsuta at varying densitites

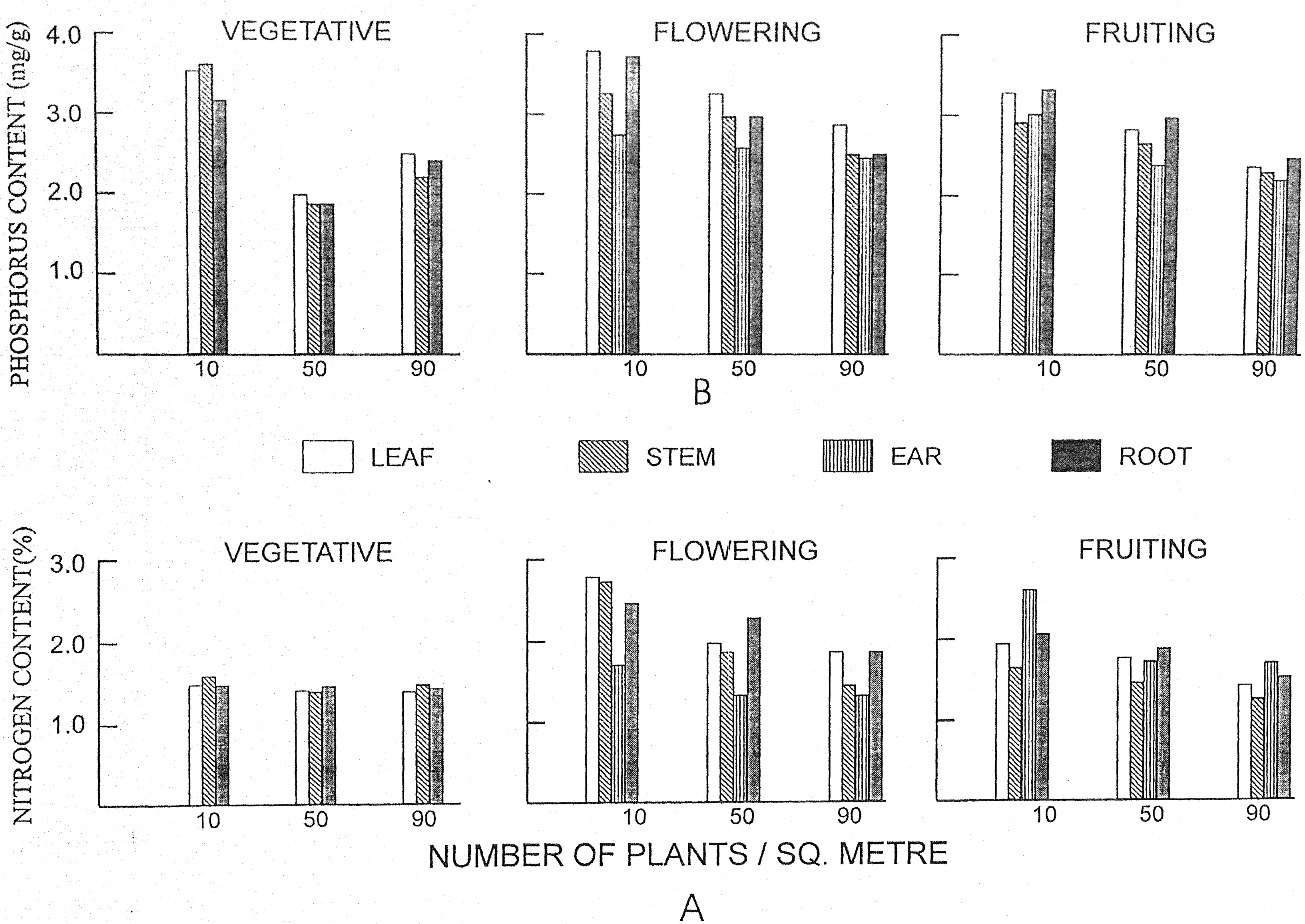
Stage	Density (per pot)	Nitrogen content (%)			Phosphorus content (mg/g)		
		Leaf	Stem	Root	Leaf	Stem	Root
Vegetative	1	1.46	1.58	1.45	3.65	3.68	3.50
	10	1.36	1.42	1.36	3.46	3.42	3.25
	15	1.25	1.41	1.25	3.22	3.14	3.16
	20	1.25	1.32	1.16	2.94	2.75	2.98
Flowering	1	2.82	2.75	2.25	3.75	3.66	3.68
	10	2.75	2.62	1.96	3.50	3.52	3.62
	15	2.66	2.25	1.75	3.26	3.18	3.48
	20	1.95	2.00	1.64	2.98	3.00	3.22
Fruiting	1	1.75	2.00	2.25	2.25	2.31	2.62
	10	1.50	1.82	1.92	2.16	1.96	2.32
	15	1.42	1.66	1.75	1.82	1.75	2.14
	20	1.21	1.46	1.46	1.75	1.66	1.68

INTERSPECIFIC COMPETITION

(A) EFFECT OF PATTERNS OF DISTRIBUTION ON DRY MATTER PRODUCTION OF WHEAT

Present data shows that dry matter production of wheat per unit area is significantly affected by the various patterns of distribution of wheat and Vicia hirsuta in mixed cultures. Highest yield was obtained in the pattern (3) in which 1 wheat plant was surrounded by two plants of wheat and 4 plants of Vicia hirsuta in every hexagon, and next to this arrangement

Fig.6.3 : Variation in A. nitrogen content (%) and B.phosphorus content (mg/g) with varying densities of wheat in pure cultures.

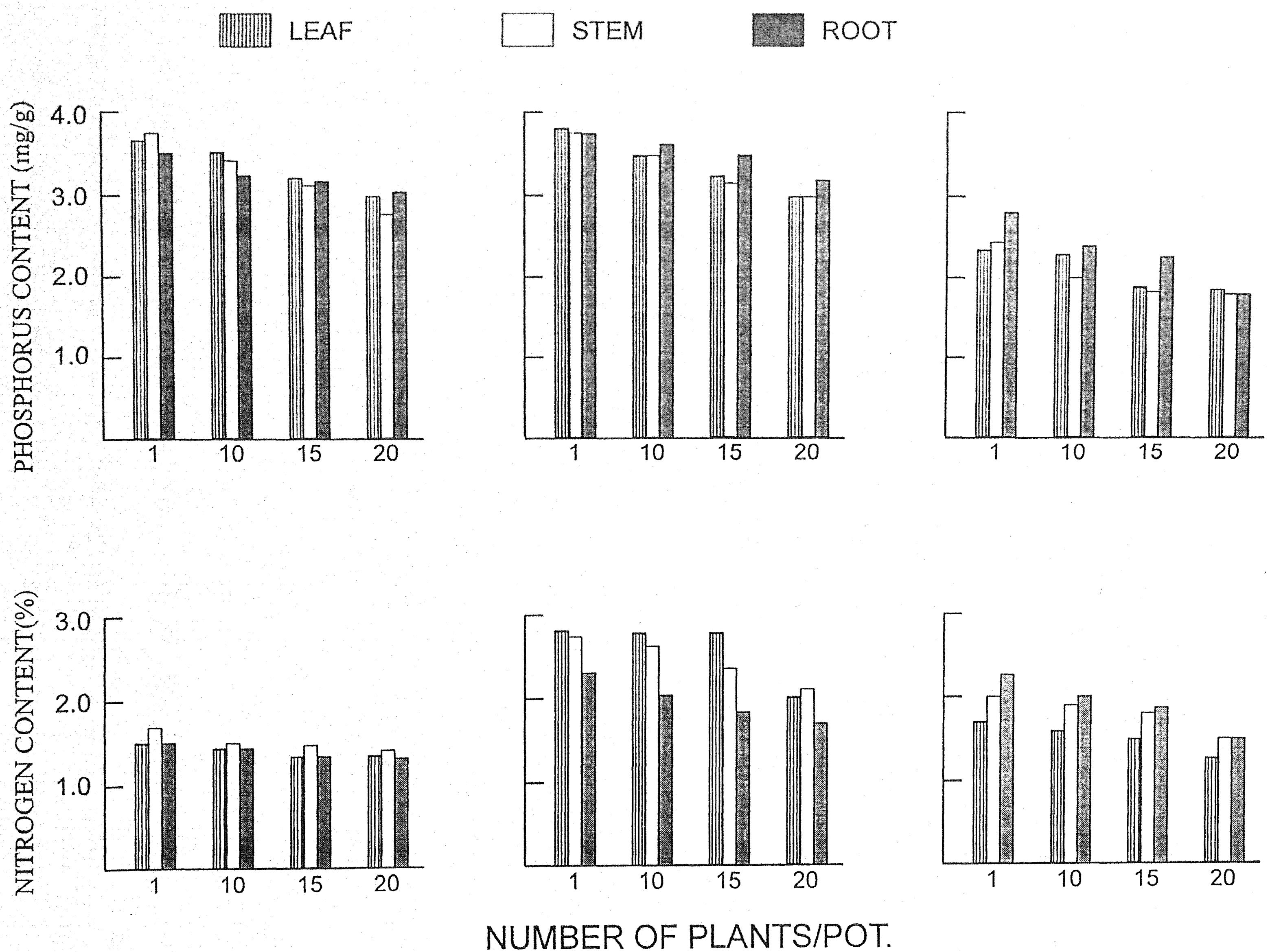

PHOSPHORUS CONTENT (mg/g)
4.0
3.0
2.0
1.0
VEGETATIVE
FLOWERING
FRUITING
10
50
90
B
LEAF
STEM
EAR
ROOT
NITROGEN CONTENT(%)
3.0
2.0
1.0
VEGETATIVE
FLOWERING
FRUITING
NUMBER OF PLANTS / SQ. METRE
A

in the decreasing order of yield was the arrangement in which 1 wheat individual was surrounded by three plants of wheat and three plants of Vicia hirsuta in hexagons, but further as the number of wheat individuals in hexagon increased, there was significant fall in the dry matter production of wheat. Even when the plants of two species were distributed randomly the dry weight of wheat per square meter was comparatively less than found in other arrangement (Table 6.7).

Table 6.7 : Influence of pattern of arrangement (Wheat and Vicia hirsuta) on yield of wheat

Stem of arrangement eat : (Vicia hirsuta every hexagon)	Oven dry wt. of wheat/plant					Total dry wt./plant
	Leaf	Stem	Ear	Total above ground	Root	
	1.87 +1.13	8.34 +2.27	7.91 +1.14	18.12	7.36 +2.34	25.48
	2.48 +1.17	15.19 +4.25	9.39 +2.46	27.06	12.49 +2.12	39.55
	2.90 +1.21	11.17 +2.93	13.95 +2.17	28.02	14.26 +5.91	42.28
a : random	1.95 +1.31	7.77 +2.14	6.15 +1.28	15.87	5.19 +2.11	21.06
random : Random	1.91 +0.98	10.17 +1.03	7.85 +2.43	20.86	8.94 +2.38	29.80

Fig.6.4 : Variation in A. nitrogen content (%) and B. phosphorus content (mg/g) with varying densities of *V. hirsuta* in pure cultures.


LEAF
STEM
ROOT
PHOSPHORUS CONTENT (mg/g)
4.0
3.0
2.0
1.0
1
10
15
20
NITROGEN CONTENT(%)
3.0
2.0
1.0
NUMBER OF PLANTS/POT.

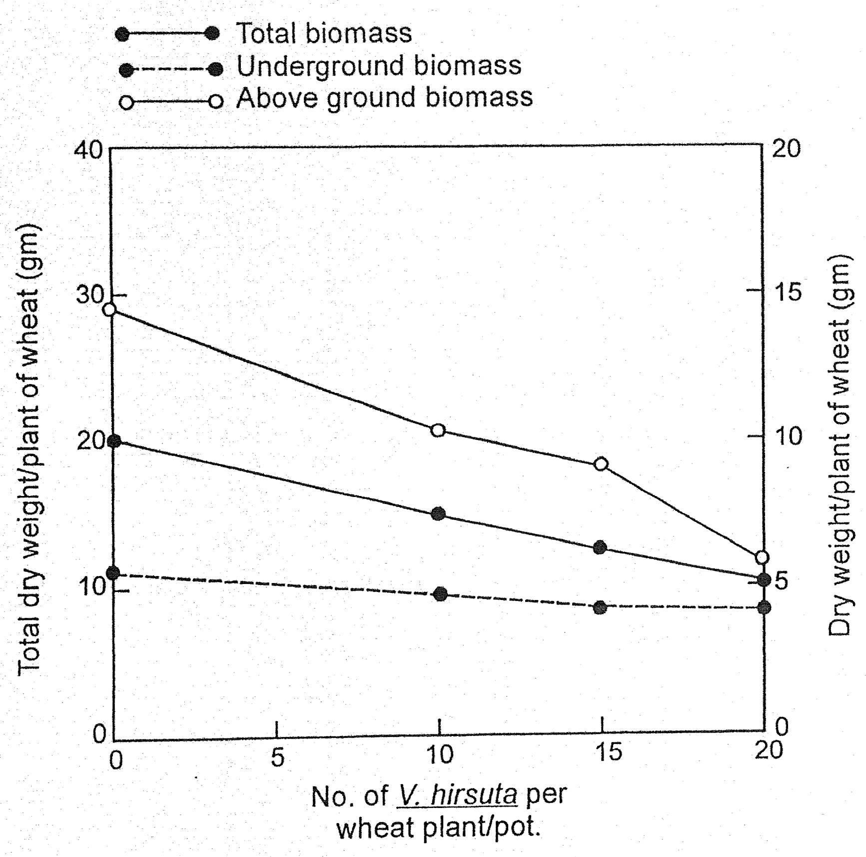
(B) EFFECT OF INCREASING DENSITY OF VICIA HIRSUTA ON WHEAT

In mixed cultures of wheat and Vicia hirsuta at varying densities there was a significant decrease in the dry weight of all plant parts of wheat as the number of Vicia hirsuta per individual of wheat increased from 10 to 20 plants per 1000 sq. cm. area. From Table 6.8 and Fig. 6.5, it is evident that total dry weight per individual of wheat was approximately 50 percent less in the set with 1 wheat + 20 Vicia hirsuta per 1000 sq. cm. as compared to that in which one wheat plant was grown per 1000 sq. cm. area. Percentage nitrogen and phosphorus contents of wheat showed a significant positive correlation with the dry weight of wheat/individual as the density of Vicia hirsuta increased. However, reduction in the percentage of nitrogen and phosphorus (mg/g) was more affected in leaves and ears of wheat (Table 6.9).

(B) EFFECT OF REPLACEMENT SERIES IN MIXED CULTURE

In mixed cultures of wheat and Vicia hirsuta in which constant total density was maintained per unit area it was found that interference due to Vicia hirsuta did not affect much the growth of wheat. On the other hand, as the proportion of wheat was increased the production of various components of wheat was affected significantly. Thus it can be concluded that in mixed clutures with constant number of total individuals in a unit

Fig.6.5: Effect of increasing density of *V.hirsuta* on the dry matter production of wheat plants.


Total biomass
Underground biomass
Above ground biomass
Total dry weight/plant of wheat (gm)
Dry weight/plant of wheat (gm)
No. of V. hirsuta per wheat plant/pot.

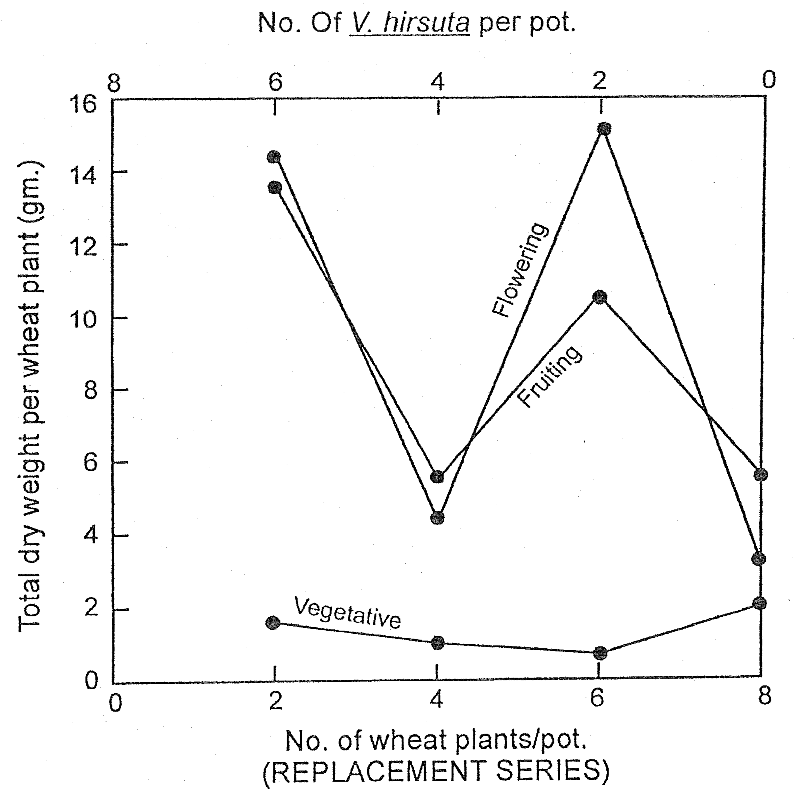

No. Of V. hirsuta per pot.
Total dry weight per wheat plant (gm.)
Flowering
Fruiting
Vegetative
No. of wheat plants/pot.
(REPLACEMENT SERIES)

Table 6.8 : Effect of increasing density of Vicia hirsuta on the growth and dry matter production of wheat

Number of plants per pot	Height (cm)	No. of ears per plant	Dry wt./plant		Total
			Above ground	Under ground	
1 wheat + no vicia	56.00 ±0.25	5.30 ±1.15	14.58 ±2.00	5.68 ±1.50	20.26
1 wheat + 10 vicia	53.10 ±0.23	3.00 ±0.25	10.11 ±2.68	4.73 ±0.21	14.84
1 wheat + 15 vicia	61.10 ±0.26	2.60 ±0.33	9.17 ±1.66	4.12 ±0.01	13.29
1 wheat + 20 vicia	50.90 ±0.21	2.30 ±1.40	6.25 ±3.00	4.05 ±0.01	10.30

Table 6.9 : Variations in percentage nitrogen and phosphorus content (mg/g) in mixed cultures of wheat with increasing density of V. hirsuta

Number of plants per pot	Nitrogen content (%)				Phosphorus content (mg/g)			
	Leaf	Stem	Ear	Root	Leaf	Stem	Ear	Root
1 wheat + 0 V. hirsuta	1.98	1.75	2.68	2.20	3.26	2.95	3.21	3.20
1 wheat +10 V. hirsuta	1.86	1.58	2.21	1.96	3.10	2.53	2.98	2.96
1 wheat +15 V. hirsuta	1.75	1.41	1.52	1.75	2.98	2.14	2.32	2.74
1 wheat +20 V. hirsuta	1.52	1.35	1.39	1.62	2.75	1.95	2.26	2.58

area. There was no significant variation due to interspecific competition but rather intraspecific effect in wheat was more marked (Table 6.10).

DISCUSSION

Planting density of crop is an important factor in determining the availability of necessary growth requirements to the crop plants. As the density increases competition among plants becomes more severe and variation in the dry matter production and nutrient uptake is marked. The above mentioned data also follow the same general trend. However, the severity of competition varies at different age. In pure cultures of wheat and Vicia hirsuta there was found a sharp decline in the (1) dry weight, (2) number of leaves, (3) number of tillers, (4) height of plants, (5) phosphorus content and (6) nitrogen content per plant at all stages of growth. On the other hand considering the total dry matter production per unit area it was observed that total dry matter production of both wheat and Vicia hirsuta increased upto flowering with increasing density in a linear fashion but at fruiting stage it also declined sginficantly after the density was increased above 50 wheat plansts/sq. meter and 150 Vicia hirsuta sq. meter. Harper (1961) on the basis of his observations of pure stands of various species concluded that the yield is not always a linear function of density it declines gradually. In the present study the decline is also gradual. Pielou (1962) stated that if interspecific competition is taking place within a plant population,

Table 6.10 :Effect of replacement series in mixed cultures on the growth of wheat individuals

Stage	No. of plants per pot	Dry wt./plant of wheat				Total
		Root	Stem	Leaves	Ears	
Vegetative	8w + 0 we	0.32 ±0.001	1.30 ±0.002	0.24 ±0.001	-	1.86 ±0.003
	6w + 2 we	0.42 ±0.240	0.19 ±0.001	0.15	-	0.66 ±0.240
	4w + 4 we	0.30 ±0.020	0.60	0.12	-	1.02 ±0.020
	2w + 6 we	0.73	0.24 ±0.001	0.45 ±0.001	-	1.42 ±0.001
Flowering	8w + 0 we	1.13 ±0.012	1.15 ±0.021	0.78 ±0.001	0.12 ±0.001	3.18 ±0.03
	6w + 2 we	6.85 ±2.150	4.77 ±2.030	3.05 ±1.130	0.05 ±0.320	14.72 ±5.32
	4w + 4 we	1.99 ±0.430	1.44 ±0.020	1.00 ±0.010	0.13 ±0.000	4.56 ±0.46
	2w + 6 we	5.42+ ±1.040	4.85 ±1.120	2.44 ±0.43	1.21 ±0.020	13.92 ±2.61
Fruiting	8w + 0 we	1.23 ±0.21	1.52 ±0.23	0.84 ±0.002	1.58 ±1.21	5.17 ±1.45
	6w + 2 we	6.92 ±1.29	1.41	1.25 ±0.001	1.04 ±0.04	10.62 ±1.30
	4w + 4 we	1.44 ±0.25	1.38 ±0.21	0.59 ±0.010	1.41 ±0.52	5.02 ±0.98
	2w + 6 we	4.31 ±1.34	4.95 ±1.08	1.14 ±0.010	3.34 ±0.01	13.74 ±2.41

w = Wheat we = Weeds

unsuccessful competitors will either be small or stunted or else completely unable to establish themselves and also the closer the two plants are to each other, the more intensely will they complete with each other. However, the present findings indicate the higher densitites of wheat and Vicia hirsuta in pure cultures did not result in the elimination of plants but affect the growth and dry matter production of individuals. Ramakrishnan (1971) has shown on the basis of his data that in wheat and Cynodon dactylon, the density stress did not result in any mortality but was observed in individual plasticity while in maize and Argemone mexicana he found strikingly evident density dependent mortality.

Pandey (1971) reported that rate of phosphate uptake varied in different plant species as well as at different periods of development which is perhaps due to the difference in the capacity and the varying demand of nutrients at different growth stages (Arnon et al, 1940; Loehwing, 1951; Hylton, 1965; Curic, 1966 and Pandey, 1971). In the present study as the density of wheat and Vicia hirsuta was increased the root growth was considerably affected, which was responsible for low rate of uptake of nutrients by these plants at higher densitites, thus limiting the dry matter production, leaf area and other growth parameters. Density of plants may further reduce a shortage of essential growth factors and shortage of these within the individuals is represented in the change of their distribution between the various growing organs of plants. In the present investigation

it was found that mineral content of leaves of infloresence is affected more by increasing intensity of competition as compared to stem and root.

Harper (1961) states that in mixed cultures besides density, different patterns of arrangement of species also affect the dry matter production. The present data shows that at a constant total density of two species in mixed clutures the pattern of distribution of wheat and Vicia hirsuta significantly affects the growth and production of wheat. In mixed stands it was also observed that competition between wheat plants themselves was more severe as compared to interspecific effects. However, in mixed cultures with varying densities of Vicia hirsuta it was found that as the number of weed plants per individual of wheat increased the dry matter production as well as total N and P content of various components of wheat was reduced markedly. This is because of the absorption of nutrients from the soil more efficiently by weed which keep an upperhand over the crop at least at the early stages of growth and the total uptake of phosphate by all the weeds growing in the immediate vicinity exceed the demands of single crop plant and affect it's growth. Pandey, Misra and Mukherjee (1971) showed that Vicia hirsuta competes with the crop at later stages of growth only. However, the present findings show that competition of Vicia hirsuta with wheat starts from the vegetative phase itself, reducing the dry matter production, nitrogen and phosphorus uptake of wheat.

From above mentioned findings it can be concluded that

competition effects are well marked in wheat crop both at intra and inter-specific levels and are evident in the production and mineral status of crop plant.

CHAPTER VII

GENERAL DISCUSSION

GENERAL DISCUSSION

(I) PHYTOSOCIOLOGICAL STUDIES

In nature no species grows singly, even crops which are raised in Monocultures have a number of associated species collectively called as weeds. These undesirable plants compete for water nutrients, space etc., with the principal crop and thus reduce the crop production. Therefore in any competition studies it is essential to understand the community structure of the cropland as a whole. Frequency and density of plants are some of the important parameters that would give a picture of the community structure. In India an ecological survey of weed flora of cultivated fields has been done by many workers (Singh and Chalam (1937), Misra (1946), Tripathi (1965) and Pandey (1968), species of weeds vary with the season of the year and stage of growth.

Two wheat fields one in the Aata Agriculture Farm ORAI and another in the surrounding area were surveyed at three important stage of growth-vegetative, flowering and fruiting. Some of the common weeds found were Vicia hirsuta, Cyperus rotundus, Cynodon daetylon, Evolvulus sp. etc. The total density of all the weeds was found to exceed that of crop at all stages of growth in both fields. The field plot situated in the Aata Agriculture Farm Vicinity (Orai) had a slightly higher density of weeds 232.7, 363.3 and 253.2/m^2 at vegetative, flowering and fruiting stages of

the crop respectively. However, in the other filed, out side the vicinity, raised by farmers, the density of weeds was comparatively low, i.e., 203.6, 296.1 and 223.7 /m^2 at the three stages of growth. These variations in the density are perhaps due to the varying soil fertility conditions and agricultural operations including periodical deweeding. At a time when active growth is going on crops require maximum nutrition and so this is the most critical period for the crop to compete with other plants. But at the flowering stage increased density of weeds limits the growth of crop.

In Aata Agriculture Farm Orai has shown on the basis of findings that Vicia hirsuta, Cyperus rotundus and Cynodon dactylon represent the dominant weed flora of wheat field. In the present work although all these species are encountered, A. tenuifolious and Cynodon dactylon are very poorly represented in both the fields at all stages of growth and therefore the most characteristic ones in order of their importance from view points of their frequency and density are C. rotundus, Vicia hirsuta and E. alsinoides.

A survey of data (Table 7.1) shows that weed flora of different wheat fields varies, although in a broad sense these are situated in the same climatic region. The crop has to face competition with different species at different stages of growth in fields, although the number of total weeds is maximum at the flowering phase of the crop. However, some of the weeds like Vicia hirsuta and C. rotundus are present throughout the growing season of the crop. So these are the most competent weeds of this crop

affecting the growth performance and dry matter yield. This work has been further extended by studying the effect of weed association on crop community specially on productive and mineral structure of the crop under field and pot culture conditions.

Table 7.1 : Dominant weed species of cultivated fields of wheat of and Aata Agriculture Farm, Orai in present work

Most dominant weeds	Dominant weeds	Wokers
A. tenuifolius, C. rotundus	Dichanthium annulatum	Pandey (1968)
A. arvensis C. dactylon C. rotundus	A. tenuifolius, Chenopodium album, Euphorbia dracunculoides, Vicia hirsuta	Tripathi (1965)
A. Vicia hirsuta C. rotundus, E. alsinoices	C. dactylon	Present work

(II) PRODUCTIVE STRUCTURE OF PURE AND MIXED STANDS OF WHEAT

(A) STANDING CROP BIOMASS AND RATE OF DRY MATTER PRODUCTION :

Potential chemical energy is accumulated in the plant body in the form of dry matter and the standing crop biomass of the crop at any time represents the amount of net dry matter accumulation upto that time However, accumulation of biomass depends on the efficiency of plants to utilize the resources of the surrounding enviornment i.e., light, water, nutrients space etc. In cropland ecosystem the dry matter production of wheat is significantly affected by weeds growing in association with it. In the pure stand of wheat (var. WH-147) the total production during the season was 247.39 g/m^2 but when weeds were allowed to grow with same density of wheat, wheat produced 1905.11 g/m^2 of dry matter recording a fall of 569.28 g/m^2. However, weed production was 285.85 g/m^2 and thus the net fall in community production in mixed stand was 283.43 g/m^2 which shows that overall efficiency to produce dry matter is considerably lower as compared to pure stand. Dwivedi (1970) has recorded a fall of 641.47 g/m^2 in the productivity of wheat (var. S. 308) in mixed stand as compared to pure stand when the total production in pure and mixed stand was 1492.06 g/m^2 and 850.59 g/m^2 respectively. Although the total production is considerably lower in var. S. 308 as compared to WH-147 still it is

notable that in var. S. 308, the reduction due to weed interference is 57 percent as compared to a lower value of 23 percent only in WH-147 wheat, which means that WH-147 is a better competent against weeds as compared to var. S. 308. When optimum condition of water and nutrients is maintained in both stands, these reductions in production of wheat are obviously because of sharing of some of the resources by weeds in mixed stands.

The productive potential of different varieties of wheat varies considerably (Table 7.2).

Table 7.2 : Dry matter production by different varieties of wheat

Species	Yield g/m²	Workers
Wheat (Triticum aestivum PS	2474.39	Present investigation
var. WH-147	MS 1905.11	" "
Wheat (T. aestivum)	PS 1492.06	Dwivedi (1970)
var. S. 308	850.59	" "
Wheat (Tritioum sp.)	1371.40	Varshney (1970)
Wheat (var. K. 68)	1905.15	Misra and Pandey
(var. S. 308)	2037.18	(1970)
Wheat 17. VII	934.00	Ross and Nilson (1966)

An analysis of the above table shows that the variations in different varieties as well as in the same variety of wheat grown under different

cultural conditions is considerable (as in S. 308). According to the above results WH-147 is the most productive species of wheat producing 2474.39 g/m^2 in PS while 17. VII is the variety producing lowest amount of dry matter i.e., 934.00 g/m^2. Differences in productivity may be attributed to two factors - (i) due to vanietal difference, (ii) variations is elimatic, edaphic conditions, agricultural operations, planting density etc.

In pure and mixed stand of wheat dermination of total dry matter gives only an idea of the total reduction in the crop weight but in order to find out the effect of weeds and the biomass of different components of wheat (leaf, stem, ear and root) in different vertical profiles of crop, a study of the productive structure of the crop is needed. Ross and Nilson (1966) stated that the assessment of the photosynthetic activity of a crop and its yield requires a determination of the dry weight of all the plant organs. Besides, measurement of the wet and dry weight according to the layers of the stand and the individual plant organs make it possible to follow their variation in water content and translocation of assimilates.

In the present investigation attempt has been made to understand reduction in the production of different components and also total dry matter of wheat at different strata due to weed association (Fig. 4.2). A significant reduction in the production of all components at all strata was found (Table 4.2).

Stratified distribution of total biomass in different crops have been

given by Ross and Nilson (1966). On the basis of their results it is noted than in most of the crops the dry biomass decreases with increasing height except in some as in horsebeans which has maximum biomass in middle layers. However, the results of the present investigation on wheat do not follow any of these distribution patterns but show maximum concentration of dry matter in top most and bottom layers in both pure and mixed stands (Table 7.3; Fig. 3). These findings are contrary to those of Ross and Nilson (1966), showing inverse relation of biomass with height in wheat. This pattern however is possible only when inflorescence production in wheat is not taken into account (Table 7.3).

Besides total dry matter production, rate of production of wheat is also significantly reduced in mixed stand as compared to pure stand throughout the growing season. Rate of production increases linearily from vegetative stage from 102.78 $g/m^2/35$ days in PS and 76.93 $g/m^2/35$ days in MS to 1417.53 1076.40 $g/m^2/35$ days at flowering stage but after this stage it again falls down to 951.08 and 751.78 $g/m^2/35$ days at fruiting stage in PS and MS respectively. Thus the period of rapid growth is the flowering phase of the crop when the rate of production of the crop is highest (Table 4.5).

Table 7.3 : Vertical distribution of total dry biomass of different crops (g/m²) in 20 layers

Layer (cm)	After Ross and Nilson (1966)					Present work	
	Horsebeans		Wheat	Sweet clover	Brome grass (wet wt.)	Wheat (var. WH-147)	
	17.VII	10.IX	17.VII	20.VIII	13.VII	PS	MS
180-200	—	—	—	59	—	—	—
160-180	—	—	—	118	—	—	—
140-160	—	—	—	230	22	—	—
120-140	—	14	—	329	44	—	—
100-120	—	59	107	255	75	—	—
80-100	63	94	108	206	151	486.58	391.92
60-80	59	171	121	206	222	464.47	329.31
40-60	41	139	176	245	259	261.42	210.32
20-40	39	65	232	281	260	307.04	239.10
0-20	42	92	190	342	376	384.46	278.14
Total	244	634	939	2,271	1,409	1903.97	1448.79

(B) PHOTOSYNTHETIC AREA INDEX

Radiant sun energy can be fixed only by green plants. Ones capable of fixing the radiant energy of sun. Thus the area of green surface of the plants and the ratio of area of green part and the land area which

it occupies is important index for determining the overall production efficiency. In most of the plants leaves are the only photosynthetic organs but in many herbs and monocots green stems and ears also take active part in photosynthesis. Throne (1962), Archbold (1942), Enyi (1962), Quinlan and Sagar (1965), Voldeng and Simpson (1967) and Asana and Mani (1950) have shown significant contribution of green stems and ears of wheat to the total grain dry weight. In the present study the maximum total photosynthetic area index of wheat was 12.51 and 9.39 in PS and MS respectively, while leaf area index was only 2.69 and 1.74 is PS and MS respectively (21.5) and 18.5% of the total Pho. A. I.). This means that rest of the photosynthetic area index i.e., 78.5 percent in PS and 81.5 percent in MS in contributed by stems and ears which is about four times that of leaves.

Photosynthetic area index of wheat is affected by the age of the crop in both stands. First it increases as the plant grows upto flowering stage and attains its maximum value of 12.53 and 9.39 in PS and MS respectively; but as the age advances, the older parts of plants become sensecent and formation of grains starts. At this time the photosynthetic area index falls down to a value of 7.24 and 4.55 in PS and MS respectively, and ultimately at the time of harvest it presumably reaches zero value. However, this value has not been recorded in the present investigation. Leaf area index also follows the same trend as the photosynthetic area

index. At fruiting stage leaf area index of wheat was 0.72 and 0.59 in PS and MS respectively. These values are comparable with those given by Ross and Nilson (1966) and Dwivedi (1970) for wheat (0.8). There was found a positive correlation of photosynthetic area index with the production of wheat in both stands (Fig. 4.5). Thus as the photosynthetic area index increases, production also increases. Watson (1952) has also reported a positive correlation of leaf area with the rate of production in wheat and barley. He has shown that the maximum leaf area in both species occurred at the time of rapid shoot elongation but after ear emergence it falls down to 2/3rd its maximal value. Donald (1963) obtained the maximum leaf area index (3) at the time of rapid shoot growth after ear emergence about half the maximum value and at harvest zero in wheat and Pandey.

The distribution of photosynthetic area index in different vertical layers of the stand, varies with the age of the crop in different layers. The overall pattern of vertical distribution shows an upright pyramidal pattern showing maximum at the base and minimum at the top. However, leaf area index is maximum in the 40-60 cm layer i.e., 9.80 in PS and 20-40 cm layers in MS i.e., 0.47 at fruiting stage but decreases towards top layers to minimum value (Table 4.7). Similarly at fruiting stage maximum value of leaf area index is 0.24 in 40-60 cm layer in PS and 0.21 in MS in the same layer. Stem area index follows the same pattern as Pho. A. I. that is maximum at the base and minimum at the top in both stands.

The photosynthetic area index of weeds in MS was comparatively very low i.e., 0.33 and 0.36 at vegetative and flowering stages respectively and at fruiting stage of crop it was reduced to zero. It implies that weeds complete their life cycle earlier than wheat and when the crop reaches fruiting stage weeds become senescent and produce seeds.

(C) LIGHT PENETRATION, CHLOROPHYLL AND WATER CONTENT IN PURE AND MIXED STANDS OF WHEAT

Where as light and chlorophyll are two essentials for photosynthesis, water is essential for translocation of minerals in the plant body. A positive correlation of chlorophyll content with dry matter production at all stages of growth was found (Bray, 1960; Leith, 1965; Medina and Leith, 1964). Thus the more productive the stand, on the basis of dry matter, it is also more productive for chlorophyll content. In the present investigation dry matter production of wheat is found to be influenced by the amount of chlorophyll in wheat i.e., the redcution in chlorophyll content in mixed stand is responsible for reduced production of wheat in MS as compared to pure stand. Besidses, in the same stand, the rate of dry matter production at all stages of growth is influenced by the amount of chlorophyll at that stage. In wheat rate of dry matter production increases from vegetative to flowering stage i.e., from 102.78 to 1417.53 $g/m^2/35$ days in PS and 76.93 to 1076.40 $g/m^2/35$ days in MS respectively and chlorophyll contents are

11978.99 and 7647.22 mg/m^2 in PS and MS respectively. But soon after ripening of ears in both stands, rate of production declined (951.08 in PS and 751.78 g/m^2) with a corresponding decrease in the chlorophyll content (10751.52 mg/m^2 in PS and 711.67 mg/m^2 in MS) in both stands (Tables 4.4 and 4.11).

There is an inverse relation between chlorophyll and light as shown by Robinowitch (1949), Whittaker and Garfine (1962). But the present findings are contrary as the total chlorophyll content (mg/m^2) increases from lowest layer to middle layers and is maximum at 40-60 cm level (2078.70 and 1074.27 gm/m^2 in PS and MS respectively. But at higher levels it decreases. These findings show that lower layers which are able to get a comparatively low intensity of light are capable of synthesizing more chlorophyll while upper layers contain comparatively low amount, showing that development of chlorophyll requires low light intensities. Robinowitch (1949) has shown that photoxidation of chlorophyll b is more rapid as compared to that of chlorophyll a. However in the present work both chlorophyll a and b decrease in the top layers due to higher illumniation. Very low amount of chlorophyll in lower layers of both PS and MS are (1) due to very low light intensity reaching these layers, and (ii) due to senescense of older parts. However, data on the vertical distribution of chlorophyll content in crops are very rare and present investigation is therefore valuable in providing information about the chlorophyll and light distribution in

different layers and their relation to production of crop.

Chlorophyll concentration (mg/g) has a positive correlation with the percentage of water in both stands and concentration of chlorophyll (a and b) varies with the age of the crop as the water content (%). As the water content of the crop decreases, chlorophyll degrades resulting in the senescence of plants (Tables 4.5; Fig. 4.5). As regards the distribution of chlorophyll (mg/g) in different layers of the crop stand, at flowering stage it was maximum at the top but at fruiting, when the ripening of grains started, chlorophyll concentration in upper layers fell down and maximum concentration was found in middle layers 40-60 cm.

Distribution of percentage water content in various components of wheat in both stands show an increase from bottom to upper layers. However percentage of water varied with age in all components of wheat as well as weeds and was maximum at the flowering stage of growth.

Bray (1960) has compared the chlorophyll content (g/m^2) of various communities (Table 7.4) and has shown that amongst them maximum chlorophyll occurs in Zea mays field and in conifer hardwood forests.

The values found for wheat in the present investigation are too high as compared to those given by Bray (1960) for different communities. It may be due to additional amount of fertilizers added to these fields which increase the development of chlorophyll. It also gives a reason for the highest production of wheat (var. WH-147) (Table 7.2) as compared to other varieties.

Table 7.4 : Chlorophyll content (g/m²) of various different communities of world)

Communitiy	Chlorophyll g/m²	Workers
Cropland (Zea mays)	2.66	Bray (1960)
Abandoned crop fields	0.30-0.59	" "
Stable prairies	0.74	" "
Savannah	0.59-1.02	" "
Closed canopy forest	3.08	" "
Pure stand of wheat	10.75	Present investigation
Mixed stand of wheat	7.11	" "

Thus the study of productive structure in order to asses the effect of weed competition, privides valuable information, as to how the production of the crop is affected by weed interference and in what way weeds reduce the production of dry matter by reducing the chlorophyll, photosynthetic area and water content of crop plants are explained by the present work.

(III) MINERAL STRUCTURE OF PURE AND MIXED STANDS OF WHEAT

Besides light, water etc., amount of nutrients is another important factor influencing the growthe and production of plants. Weeds in crop fields absorb some quantity of minerals from the soil thus reducing the availability of these to the crops. The low nutrient status of soil ultimately

results in reduced nutrient content in plants, thus affecting the quantity of economic products i.e., grains, forage etc.

DISTRIBUTION OF NITROGEN AND PHOSPHORUS IN PLANT BODY

Nitrogen and phosphorus are the important elements taking active part in metabolic processes. Distribution of these in different components of wheat varies with the age of the crop. At vegetative stage (35 days) distribution of nitrogen and phosphorus in the plant body is almost uniform in both the stands with only insiginificant variations; but as the crop advances in age the concentration of nitrogen and phosphorus becomes significantly lower in MS as compared to that in pure stand. The nitrogen and phosphorus are withdrawn from the older portions (non-green parts) to newly growing regions (which have a relatively high percentage of nitrogen and phosphorus) thus reducing its concentration in old parts (Tables 5.1 and 5.2).

The vertical distribution of nitrogen and phosphorus shows an upward flow of these elements in wheat. Biddulf (1959) has pointed out that mineral redistribution in plants may be either due to withdrawl from leaves before fall or due to transfer of elements from vegetative portions to reproductive parts. In wheat also, due to withdrawl of nutrients from non-green parts, the concentration is high in growing regions at flowering stage, but at fruiting stage ears have the highest concentration of both nitrogen

and phosphorus due to the movement of these elements from all other components to the ear. These findings also show that accumulation of nitrogen and phosphorus in ears at maturity depends on the concentration of these in vegetative parts at younger stages of growth. Hirose (1971) has shown that in Solidagago altissima population nitrogen content is maximum in middle layers while in wheat it increase from lower to top layers at all growth stages, i.e,, an upward translocation of nitrogen takes place. A study of mineral structure of PS and MS of wheat provides valuable information of the translocation of nitrogen and phosphorus in wheat and at the same time influence of weeds on the translocation, uptake release and retention of these nutrients in the wheat crop.

UPTAKE, RELEASE AND RETENTION OF NITROGEN AND PHOSPHORUS

Weeds absorb considerable amounts of nitrogen and phosphorus in mixed stands while uptake of nitrogen and phosphorus by wheat in significantly reduced in mixed stand as compared to pure stand at all stages of growth. The variation in the uptake of nitrogen and phosphorus with age follows the same trend in both stands i.e., the uptake is maximum at flowering stage i.e., 28796.5 and 17472.3 nitrogen/mg/m^2 in PS and MS respectively and 7135.35 and 4519.50 mg/m^2 of phosphorus in two stands respectively. These findings also show that uptake of nitrogen is about four

times more, than that of phosphorus which indirectly indicates that nitrogen requirement of wheat plants is much higher than phosphorus in required. As both these elements take active part in metabolic activities of plants, maximum uptake of these at flowering stage shows that this is the stage at which metabolism of plants is highest. Gregory (1926) stated that over 90 percent of the total nitrogen and phosphorus was taken up when the dry weight was only 25 percent of the total value. However, in the present investigation when about 60 percent of the dry weight of wheat was accumulated, only 58 percent of the total nitrogen and 65 percent of the total phosphorus was taken up by wheat plant. The release of nutrients did not occur at vegetative stage because there was no litter fall at this stage.

An examination of the Table 7.5 shows that uptake of phosphorus is maximum in pure stand of wheat although the value found in the present investigation are much higher than the findings of other workers. It may be due to the verietal difference, degree of fertilization, density of plants, etc. It is also seen that uptake release and retention values of wheat are maximum as compared to those of other species. However the nitrogen uptake is higher in Pinus sylvestris plantations which is obviously due to fertilization; but still the amount of nitrogen retained is very low as compared to wheat. This is due to the fact that in wheat litter fall is very little and so the amount released is also low but on the other hand in forests and grassland large amount of litter falls on the ground releasing the nitrogen into the soil.

Table 7.5 : Uptake, release and retention of phosphorus in different plants

Plants		Phosphorus kg/ha			Workers
		Uptake	Release	Retention	
Triticum aestivum	PS	116.25	36.82	79.43	Present work
(Var. WH-147)	MS	74.84	25.10	49.76	
T. aestivum	PS	71.19	12.19	59.00	Dwivedi (1970)
(var. S. 308)	MS	36.74	9.18	29.56	
Dichanthium	PS	54.48	5.23	49.25	Dwivedi (1970)
annulatum	MS	15.77	2.48	13.15	
T. aestivum (shoot)		16.05	—	—	Hestner and Shelton (1949)
T. aestivum (N.P. 52) (Shoot)		31.41	—	—	Singh (1963)
Horse beans (Shoot)		25.81	—	—	Barker Dillinger (1937)
Sugarcane (Shoot)		39.27	—	—	Uexkull (1963)
Birch tree (Shoot)		11.00	6.00	5.00	Smirnova and Gordodentseva (1958)
Tropical deciduous forest		18.00	14.00	4.00	Misra (1969)

Table 7.6 : Uptake, release and retention of nitrogen in different plants

Plants		Nitrogen kg/ha			Workers
		Uptake	Release	Retention	
Birch (U.S.S.R.)		111.00	59.00	33.00	Smirnova and Gorodentseva (1968)
Dry steppes		45.00	45.00	—	Rodinand Bazilevich (1968)
Dry savannahs		81.00	80.00	1.00	" "
<u>Pinus</u> <u>sylvestris</u>		687.50	633.40	54.10	Ovington (1962)
Wheat	PS	528.00	162.33	365.67	Present work
	MS	270.14	68.75	201.38	

Further, it is evident from the percentage nitrogen and phosphorus content of different components of wheat that concentration is more in newly growing parts and is reduced considerably in older parts towards ground level. From this we can conclude that concentration of these minerals (N and P) is higher in the meristematic regions of plant which are more active physiologically while these (N and P) are withdrawn from older parts which are relatively inactive. Thus the translocation of minerals occurs from basee towards top in wheat plants and maximum accumulation is in

inflorescence. Dead leaves and roots were considered as litter because although non-green stems of wheat were also present but the stems even after senescence do not fall on the ground, as litter. The release of nitrogen through litter fall was maximum at fruiting stage of the crop i.e., 1557.90 and 6543.00 mg/m^2 of nitrogen and 3479.62 and 2407.66 mg/m^2 of phosphorus in PS and MS respectively. Amount retained by wheat crop was maximum at flowering phase i.e., 28796.5 and 17472.3 mg/m^2 of nitrogen and 7135.35 and 4519.50 mg/m^2 of phosphorus in PS and MS respectively.

(IV) INTRA AND INTERSPECIFIC COMPETITION

Spacing in a crop field is an important problem determining the production of the crop. In field cultures where all the weeds compete against the crop plants due to very high density of plants, the reduction in crop production is significant. The phytosociological studies of the present investigation show that Vicia hirsuta is one of the dominant weed of wheat fields of study area this region. Therefore competition of wheat with Vicia hirsuta as influenced by different factors i.e., density, distribution pattern etc., was studied in pure and mixed cultures. Production of the crop under the influence of competition is also affected by the age of the crop. In pure cultures of wheat and Vicia hirsuta there was a sharp deeling in the dry weight, leaf, number of tillers, height of plant and nitrogen and phosphorus

content of individual plants throughout the growing period, but when total dry weight per pot is taken into account, is shows an increasing trend upto flowering stage but then it declines significantly after an increase in density above 5 wheat and 15 Vicia hirsuta individuals per pot to 9 wheat and 20 Vicia hirsuta plants per pot. This means that optimum density for obtaining maximum production in pure cultures is between 5 and 9 wheat plants per pot (50 and 90 plants/m^2) and 15 and 20 plants of Vicia hirsuta (150 and 200 plants/m^2).

In mixed cultures, the productivity, nitrogen and phosphorus contents in individual wheat plants decrease with increasing density of Vicia hirsuta per wheat individual. Many earlier workers have tried to assess the effects of competition between species with closely related habits (Harper and Mcnaughton, 1962; Harper, 1961 etc.). But Vicia hirsuta which is a dicatylednous plant species with different growth habit as compared to wheat, is also a good competetor of wheat when mixed cultures of these were grown.

However, in mixed cultures of wheat and Vicia hirsuta maintained at a constant total density but with varying densities of two component species the intraspecific effect of two species was more obvious as compared to interspecific effect and production of wheat was reduced in sets which had maximum density of wheat.

Besides density effect, spatial pattern of distribution of two plant

species also affects the production of wheat but even these results show that when total density is constant, the production of wheat is affected significantly in those patterns in which number of wheat plants in the hexagon is more as compared to Vicia hirsuta i.e., intraspecific effect is more severe.

Thus it can be concluded that in wheat crop although intraspecific as well interspecific competition (with Vicia hirsuta) occurs and significantly affects crop yield, still it is apparent that Vicia hirsuta competes with wheat only when the density of Vicia hirsuta is much higher as compared to wheat.

These findings and of field studies show (described in chapter VI) that effect of weed competition is more evident in field conditions where the number of weed species exceeds that of wheat as compared to pot cultures where only one weed species is competing against wheat. The effects of competition with weeds reduce the crop production both quantitatively as well as qualitatively (production of dry matter, reduction important nutrients like nitrogen and phosphorus) which reduce the economic value of the crop. Therefore it can be concluded on the basis of the above facts that to increase the economic return of the wheat fields, competition of crop plants with other species should be reduced to a certain minimum level as discussed in the preceeding pages.

CHAPTER VIII

SUMMARY

SUMMARY

The present investigation was conducted at Aata Agriculture Farm, Orai (Jalaun), Uttar Pradesh situated at lat 25^0 59' N, long 79^0 37' E and at about 125 m above mean sea level in Bundelkhand region. The study area was fully protected from all the type of biotic interferences.

In order to obtain quantitative information on the influence of competition, production, species structure, productive structure (dry matter production, chlorophyll, water, light and photosynthetic area at different vertical strata) and mineral structure (nitrogen and phosphorus status and their flow) of wheat in pure stand and mixed stand of wheat and weeds have been studied. Besides field studies, pot culture studies were also done to study the influence of competition factors like density, distribution pattern etc. on the production of wheat.

Computation of water balance of the study area was made following the method proposed by Thornthwait and Mather (1955) and the ecoclimatic formula as $C_1A_2a_2s$ indicated dry sub-humid climate.

The soil of the study area is slightly alkaline, pH range from 7.60 to 7.70 and it is pale brown in colour Sand content is higher than other aggregates. Nitrogen and phosphorus percentage decreases with soil depth. A summary of the present findings has been in Fig. 7.1 and stated as below :

PHYTOSOCIOLOGY

The phytosociological analysis (density, frequency) of two wheat fields showed that Vicia hirsuta, Cyperus rotundus, Cynodon dactylon and Evolvulus alsinoides are the most common weeds of these fields. The total density of all weeds exceeded that of crop at all growth stages. Density per square metre of weeds varied at different stages of crop i.e. 232.7 and 203.6 at vegetative stage; 363.3 and 296.1 at flowering stage and 253.2 and 223.7 at fruiting stage in the two fields respectively. This shows that at folwering stage density of weeds is highest in both fields.

NET DRY MATTER PRODUCTION

The total net dry matter production of wheat during the season was 2474.39 and 1905.11 g/m^2 in PS and MS respectively while weeds produced 285.85 g/m^2 of dry matter. Therefore, loss in wheat in mixed stand is 569.28 g/m^2 but the net fall in community production was 283.43 g/m^2. This net production shows that overall efficiency to produce dry matter is considerably lowered in mixed stand due to weed interference.

BIOMASS STRATIFICATION (VERTICAL DISTRIBUTION)

The vertical distribution of dry matter in different components of wheat (leaf, stem, ear and root) in PS and MS show that there is significant reduction in all components of mixed stand at all strata.

Vertical distribution of total dry matter of wheat shows that biomass is very high in top most and bottom layers and low in the middle layers in both stands.

RATE OF DRY MATTER PRODUCTION

Rate of dry matter production is significantly reduced in mixed stand as compared to pure stand at all the growth stages i.e. 102.78 in PS and 76.93 $g/m^2/35$ days in MS at vegetative stage, 1417.53 and 1076.40 $g/m^2/35$ days at flowering stage and 951.08 and 751.78 $g/m^2/35$ days at fruiting stage in PS and MS respectively these finding shows that the rate of production increases upto flowering stage and then falls down after this stage in both stands.

PHOTOSYNTHETIC AREA INDEX

The maximum total photosynthetic area index of wheat is 12.51 and 9.39 in PS and MS respectively while leaf area index was 2.69 and 1.74 in PS and MS respectively. Thus 78.5 percent of the photosynthetic area index in PS and 81.5 percent in MS is contributed by green stems and ears only. The photosynthetic area index of wheat is maximum at flowering stage and then declines. The pattern of vertical distribution of Pho. A.I. shows an upright pyramidal pattern i.e., maximum at base and minimum at the top. The Pho. A.I. of weeds in MS was 0.33 and 0.36 at vegetative

and flowering stages respectively but at fruiting stage it was reduced to zero.

CHLOROPHYLL CONTENT

Chlorophyll content was maximum at flowering stage of crop i.e. 11978.99 and 7647.22 mg/m^2 in PS and MS respectively but at fruiting stage it decreased to 10751.52 in PS and 711.67 mg/m^2 in MS. Total chlorophyll content (mg/m^2) increases from lowest layer to middle layers (40-60 cm) i.e. 2078.70 and 1074.27 mg/m^2 in PS and MS respectively.

Concentration of chlorophyll (mg/g) has a positive correlation with the percentage water content in both stands.

WATER CONTENT PERCENTAGE

Distribution of percentage water content in various components of wheat in both stands shows an increase from bottom to upper layers. However, the percentage of water varied with age in all components of wheat as well as weeds and was maximum at flowering stage. The percentage water content is significantly reduced in MS in all components of wheat as compared to PS.

LIGHT INTENSITY

Amount of light reaching the ground surface was comparatively low in mixed stand due to presence of weeds i.e. 65 and 50 percent at

vegetative stage, 15 and 5 percent at flowering stage and 20 and 15 percent at fruiting stage in pure and mixed stands respectively.

MINERAL STATUS

Distribution of nitrogen and phosphorus shows an upward flow of these elements in wheat. The maximum concentration of these occurred in growing regions of wheat. However, concentration of these was reduced significantly in MS as compard to PS in all components of wheat.

The uptake of nitrogen and phosphorus was maximum at flowering stage i.e. 28796.5 and 17472.3 mg of N/m^2 in PS and MS respectively and 7135.35 and 4519.50 mg/m^2 of phosphorus in two stands respectively.

The release of nitrogen as well as phosphorus was maximum at fruiting stage of crop i.e. 1557.90 and 6543.0 mg/m^2 of nitrogen and 3479.62 and 2407.66 mg/m^2 of phosphorus in PS and MS respectively. The crop retained maximum amount of nutrients (N and P) at flowering stage i.e. 28796.5 and 17472.3 mg/m^2 of nitrogen and 7135.35 and 4519.50 mg/m^2 of phosphorus in PS and MS respectively.

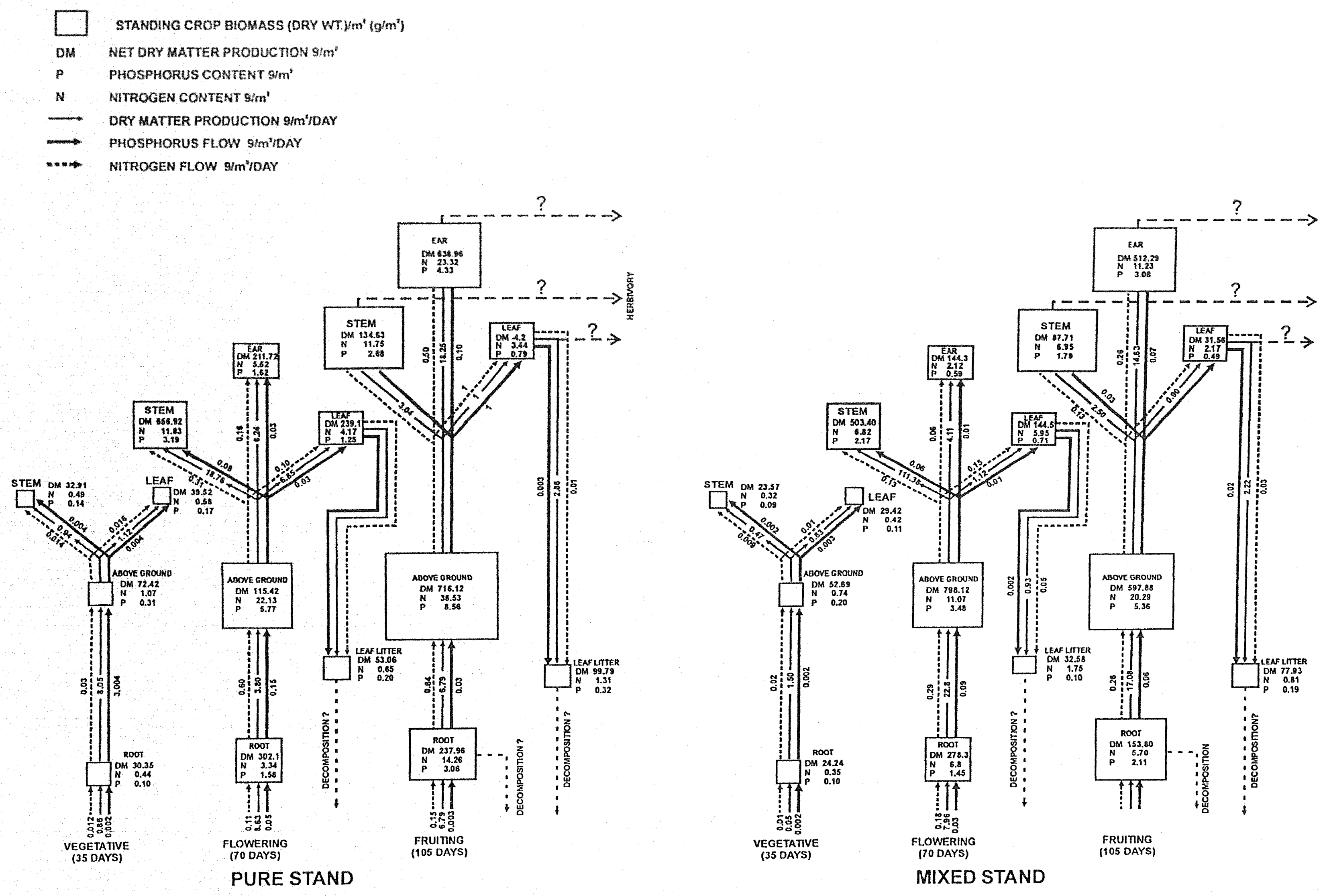
INTRA AND INTERSPECIFIC COMPTETION

Intraspecific as well as interspecific competition of wheat and Vicia hirsuta effect the production of these plants in pot cultures, still it is notable that Vicia hirsuta compete with wheat only when the density of

Vicia hirsuta is much higher than wheat in mixed cultures.

Thus, from these findings it can be concluded that in mixed cultures the production of wheat is significantly lowered both from the point of view of dry matter production as well as nutritional quality.

Fig.7.1: Productive and mineral structure of wheat in pure and mixed stands.


STANDING CROP BIOMASS (DRY WT.)/m² (g/m²)
DM NET DRY MATTER PRODUCTION 9/m²
P PHOSPHORUS CONTENT 9/m²
N NITROGEN CONTENT 9/m²
DRY MATTER PRODUCTION 9/m²/DAY
PHOSPHORUS FLOW 9/m²/DAY
NITROGEN FLOW 9/m²/DAY
STEM DM 32.91 N 0.49 P 0.14
LEAF DM 39.52 N 0.58 P 0.17
ABOVE GROUND DM 72.42 N 1.07 P 0.31
ROOT DM 30.35 N 0.44 P 0.10
VEGETATIVE (35 DAYS)
STEM DM 656.92 N 11.83 P 3.19
EAR DM 211.72 N 5.52 P 1.62
LEAF DM 239.1 N 4.17 P 1.25
ABOVE GROUND DM 115.42 N 22.13 P 5.77
ROOT DM 302.1 N 3.34 P 1.58
LEAF LITTER DM 53.06 N 0.65 P 0.20
FLOWERING (70 DAYS)
EAR DM 638.96 N 23.32 P 4.33
STEM DM 134.63 N 11.75 P 2.68
LEAF DM -4.2 N 3.44 P 0.79
ABOVE GROUND DM 716.12 N 38.53 P 8.56
ROOT DM 237.96 N 14.26 P 3.06
LEAF LITTER DM 99.79 N 1.31 P 0.32
DECOMPOSITION ?
HERBIVORY
FRUITING (105 DAYS)
PURE STAND
STEM DM 23.57 N 0.32 P 0.09
LEAF DM 29.42 N 0.42 P 0.11
ABOVE GROUND DM 52.69 N 0.74 P 0.20
ROOT DM 24.24 N 0.35 P 0.10
VEGETATIVE (35 DAYS)
STEM DM 503.40 N 6.82 P 2.17
EAR DM 144.3 N 2.12 P 0.59
LEAF DM 144.5 N 5.95 P 0.71
ABOVE GROUND DM 798.12 N 11.07 P 3.48
ROOT DM 278.3 N 6.8 P 1.45
LEAF LITTER DM 32.58 N 1.75 P 0.10
FLOWERING (70 DAYS)
EAR DM 512.29 N 11.23 P 3.08
STEM DM 87.71 N 6.95 P 1.79
LEAF DM 31.56 N 2.17 P 0.49
ABOVE GROUND DM 597.88 N 20.29 P 5.36
ROOT DM 153.80 N 5.70 P 2.11
LEAF LITTER DM 77.93 N 0.81 P 0.19
DECOMPOSITION?
FRUITING (105 DAYS)
MIXED STAND

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APPENDIX

APPENDIX

PLATE 1. A view of the wheat field at flowering stage of the crop

PLATE 2. Variation in root and shoot of wheat plant at three densities

(i) One plant/pot,

(ii) Five plants/pot,

(iii) Nine plants/pot in pure cultures

PLATE 3. Variation in size of ear of wheat grown at three densities

(i) One plant/pot,

(ii) Five plants/pot,

(iii) Nine plants/pot in pure cultures

PLATE 4. Variation in size of wheat ear grown at

(i) One wheat plant/pot,

(ii) One wheat +10 Vicia hirsuta/pot,

(iii) One wheat +15 Vicia hirsuta/pot,

(iv) One wheat +20 Vicia hirsuta/pot in mixed cultures

PLATE 1. A view of the wheat field at flowering stage of the crop

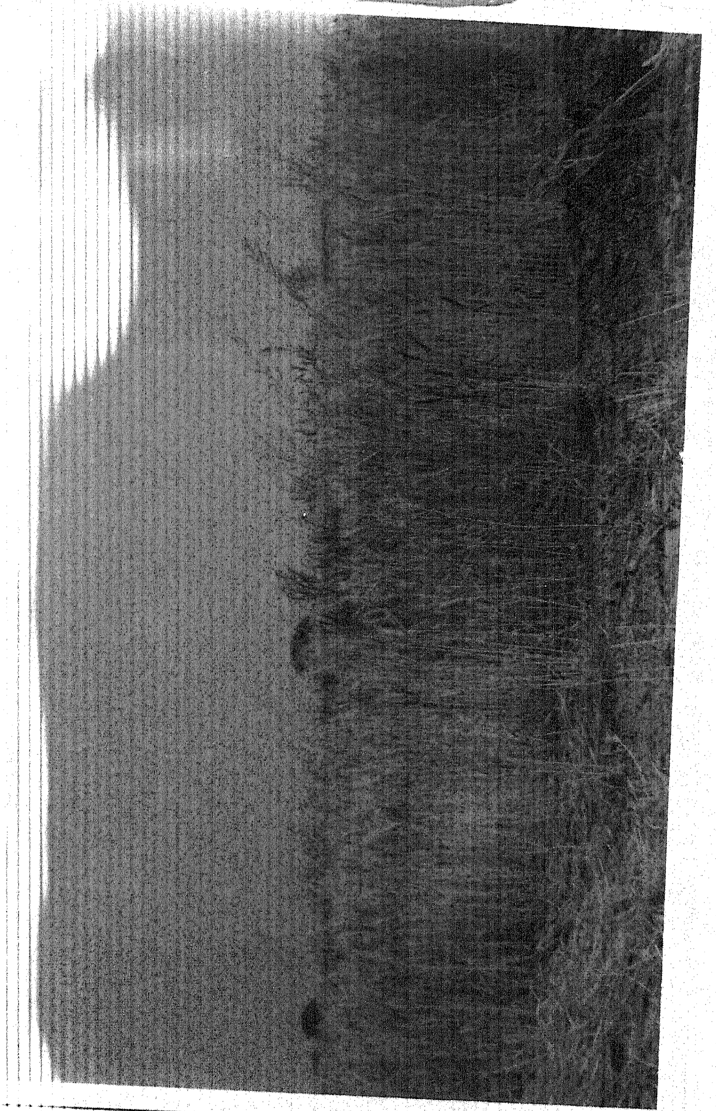


PLATE 2. Variation in root and shoot of wheat plant at three densities

(i) One plant/pot,

(ii) Five plants/pot,

(iii) Nine plants/pot in pure cultures

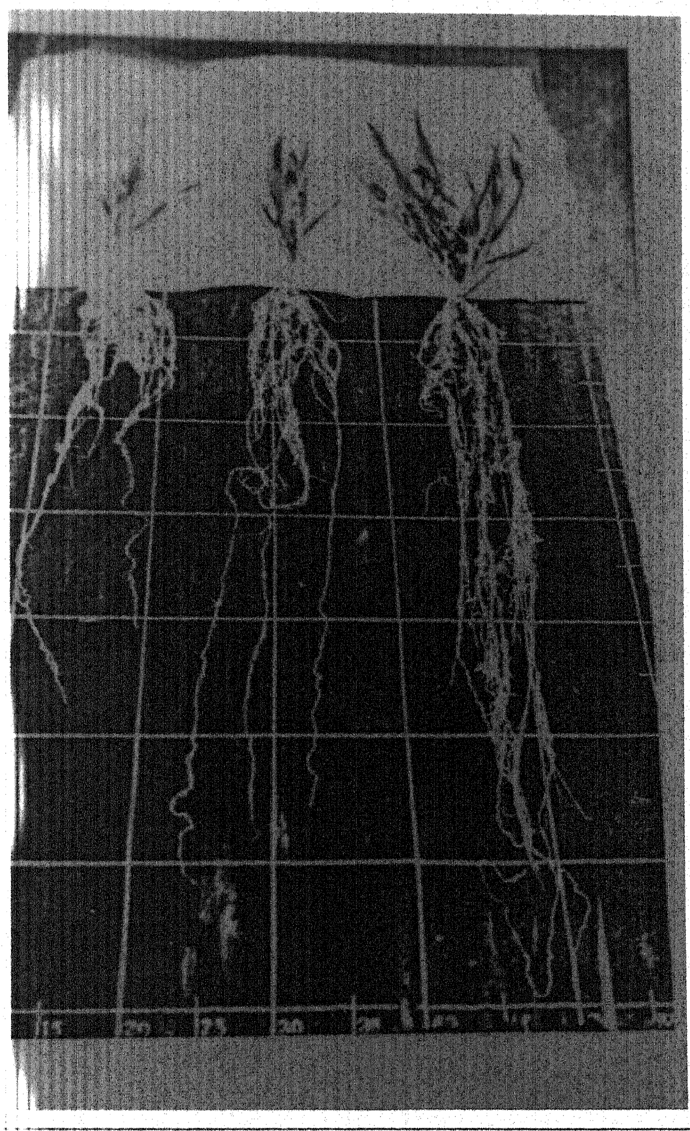
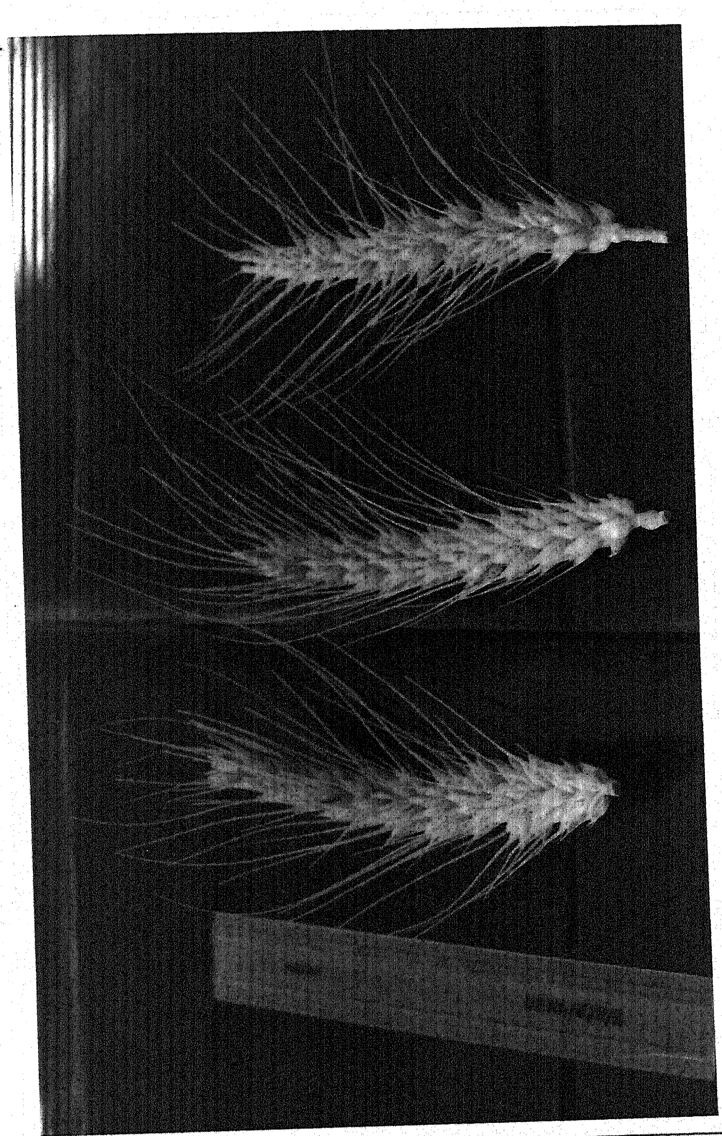


PLATE 3. Variation in size of ear of wheat grown at three densities

(i) One plant/pot,

(ii) Five plants/pot,

(iii) Nine plants/pot in pure cultures



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(i) One wheat plant/pot,

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